FEILDEN'S MAGAZINE.

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PRESIDENT McKINLEY.

DURING the interval between the appearance of our last issue and the publication of the present one, the great Republic on the other side of the Atlantic has sustained a loss, in which we should sincerely sympathise with it even if there did not exist the tie of blood between its people and our people, but, as matters stand, the assassin's blow is felt among us almost as keenly as if it had been directed against our own ruler. Whatever differences there may exist on minor points between ourselves and our trans-Atlantic friends, whatever divergency of opinion there may be amongst the two nations on political and economic subjects, in those moments in which the purely human interest survives, in the hour of great joy or of great sorrow, the blood-relationship rises superior to all lesser considerations, and we realise that we are of the same race and have a common history embracing many centuries, compared with which our separate history is but a short interval. True, the dead President whom the American nation mourns, in his political acts during the earlier part of his administration, at least, did not show himself over-friendly to this country. Not that he hated it, but he believed it to be a duty to his own native land to place obstacles in the way of the development of our trade, hoping thus to benefit that of the United States. This naturally created some antagonistic feeling among British people, together with a certain annoyance at a policy that many of our own people believed to be based on a lack of insight, and, far from benefiting the United States, would ultimately do injury to them. This, however, was instantly forgotten, we are sure, by all true Englishmen when they heard of his deplorable fate. It is true that Mr. McKinley's recent attitude with reference to economic questions had considerably changed. He had learned from experience. An Imperial policy he had seen is incompatible with narrow and selfish patriotism. In great enterprises it is better to have friends than enemies, and reciprocity is the only sound attitude toward one's neighbours in such a case. The principle of *do ut des*—*i.e.* a principle of equity—is the soundest foundation in international politics, and Mr. McKinley, though late, seemed to have thoroughly realised this fact; even if he had not, England would not have been less affected by his death, and have not mourned less sincerely with his fellow-citizens. The United States have lost in Mr. McKinley a president who had thousands of sincere friends and but few enemies, and whom the vast majority of his fellow-citizens considered a man of unusual ability. There is reason for the belief that they were right in this, as, with the experience gained in his high position at a stirring time in the history of his country, he ultimately earned also abroad the name of a talented ruler.

The policy of the new President is not yet sufficiently known to permit us to say whether Mr. McKinley's death will be even a greater calamity than is at present realised. There is an element of uncertainty in every change of government in the United States that is absent in European politics. We can but watch and wait. Meanwhile, however, our American friends may be assured that whatever sympathy finds expression in this country, it is sincere sympathy, influenced in no way by political considerations.

THE INTERNATIONAL ENGINEERING CONGRESS AT GLASGOW.

MR. JAS. MANSERGH, PRES.INST.C.E., *President of the Congress.*

We may take it as a happy omen, or, at all events, as a welcome sign of the times, that the first year of the new century should have been marked by a gathering of distinguished men from nearly all parts of the civilised world in the "Second city of the British Empire," to discuss the progress and problems of "Engineering"—problems of the highest import for the material welfare of all of us; for, however vague the idea may be that is conveyed to mankind in general by the term, and however lax may be its use among those even who themselves belong to the engineering profession, engineering is one of the chief sources of material progress and one of the most important factors of modern civilisation, upon which it has indelibly set its seal. If certain epochs in the history of man may be justly called epochs of war, of art, of commerce, of science, etc., the epoch in which we are living, and which, as yet, is in its nascent state, cannot be characterised more appropriately than by designating it as the epoch of "engineering," if we use the term in its widest sense, in which it is practically identical with applied science, or, at all events, comprises some of the most important parts of it.

The Presidential Address: The Vagueness of the terms "Engineering" and "Engineer."

This, however, is not always understood, owing to the vague way in which the terms "engineering" and "engineer" are generally used. To this fact allusion was justly made by Mr. James Mansergh, F.R.S., President of the Institution of Civil Engineers, in the address delivered by him at Glasgow as President of the International Engineering Congress, in which he remarked that of the many definitions of the words "engineering" and "engineer" that have been framed, none seemed to him adequate, and, at the same time, sufficiently exact and exclusive. Though we entirely agree with Mr. James Mansergh that the uncertain use of these terms is unsatisfactory, we cannot approve of his phraseology, for his words seem to imply that, in his opinion, there exists a well-defined branch of human knowledge and activity to which alone the term "engineering" can be appropriately given, and that all that is required is, to indicate in the lexicological paraphrase of the term the characteristic features of this theoretical and practical knowledge. Such, however, is by no means the case, and still less does the etymology of the word "engineering," whether we dwell on its relationship to "engine" or to "ingenious"—as Mr. Mansergh suggests—give us any guidance regarding its proper use. The fact is, that though we have the term, we have not yet come to a definite agreement as to its correct application. The reason of this is, that the science to which it is supposed to refer is itself only fragmentary as yet, and is merely beginning to develop a distinct nucleus from the widely diffused subject-matter that is to furnish its contents.

The Subject-Matter of "Engineering."

This subject-matter consists of what we call "applied science," and what should rather be called "applicable," or technical, knowledge. Its high importance lies in the fact that it must guide us whenever we interfere in material processes, for it rests on the laws controlling matter, and permits us to benefit by them. What

MR. EDWARD GLOVER, PRES. INST. C.E., IRELAND.

portions of this technical knowledge will ultimately be included under the term of engineering, in its more definite sense, is difficult to foretell at the present moment, but we can at least obtain a clue by deducting from existing classifications the general principles uniting the various branches of technical knowledge that so far have been included under the general heading of "engineering," and we may thus derive information even from the grotesque and irrational subdivision of the theory and practice of engineering which formed the basis for allotting work to the various sections into which the Glasgow Congress was split up. These sections were nine in number, and their work was classified as follows: 1. Railways; 2. Waterways and Maritime Works; 3. Mechanical Engineering; 4. Naval Architecture and Marine Engineering; 5. Iron and Steel; 6. Mining; 7. Municipal Engineering; 8. Gas Engineering, and, finally, 9. Electrical Engineering.

The Scope of "Civil Engineering."

Among these nine divisions, the first and second have this in common, that they both refer to the transformation of the surface of the earth, and the work directly or indirectly connected with it, for the purpose of facilitating travel and transport, by the levelling of roads and the building of bridges and viaducts, by the laying of rails and the excavation of tunnels, or, where water traffic is concerned, by the rectification of river banks, the establishment of harbours and docks, and the erecting of lighthouses, and, finally, by the dig-

MR. W. H. MAW, PRES. I. MECH. E.

ging of canals and the dredging of river beds, thus producing those comfortable conditions of locomotion and transport to which we have now become accustomed. All the above requirements of travel and traffic form important portions of the work to be accomplished by that branch of the art which is comprised under the general heading of "civil" engineering, from the word *civis* (citizen). But, besides facilities of communication and transport, there are many other requirements of "civilised" life, such as, for instance, an abundant supply of pure water for domestic use and irrigation, sewers and refuse destructors to ensure sanitary conditions, gas-works or other establishments providing for the illumination of the streets and public places at night time, and supplying, if desired, even private houses, and, finally—a comfort added in recent times—telegraph and telephone lines, for the purpose of facilitating swift verbal intercourse between persons separated by great distances from each other, not to speak of numerous minor commodities and institutions, be they necessities or luxuries, that have been created by civilisation and in their turn serve to raise to a higher and higher level the material conditions of modern mankind. All activity serving the purpose of securing these conditions by utilising to the utmost the natural resources of a country, and by rendering subservient to man for this purpose the immense forces of Nature which science has taught him to control, has, until recently—*i.e.* as long as it was customary for the Government

SIR BENJAMIN BAKER. *Pres. of Railway Section.*

MR. GEORGE BEARD, PRES. WEST OF SCOTLAND IRON AND STEEL INST.

of a State to supervise this activity—been treated under the general term of "civil engineering," and, consequently, not only the first and second of the above-given nine subjects, but also the seventh and eighth and a considerable portion of the third and ninth, were once included in this term. The extension of local government in recent years, however, and the transfer by the central government of the right and duty of providing for the health and comfort of its citizens to the various municipalities, has been the source from which the uncouth term "municipal engineering" has been derived, which is intended to apply only to such engineering work as is controlled by the local authorities. It would consequently have a different meaning in different localities, depending on the greater or lesser amount of self-government possessed by each community. By these variations, moreover, the term "civil engineering" becomes equally dependent on these conditions. All this is abnormal and extremely unsatisfactory in the establishment of scientific nomenclature.

Definitions of Engineering Criticised.

Nor is there much gained by the definitions of civil engineering proposed by those who try to ignore entirely the etymology of the word "civil" and to derive their definition from an analysis of the principles underlying the work of civil engineers. To these belongs what Mr. J. J. R. Croes, President of the American Society of Civil Engineers, in his inaugural address, recently called "the ever memorable definition of civil engineering given, in response to a request, by Mr. Tredgold in 1828," namely—

> "Civil engineering is the art of directing the great sources of power in Nature for the use and convenience of man, being that practical application of the most important principles of natural philosophy which has, in a considerable degree, realised the anticipations of Bacon, and changed the aspect and the state of affairs in the whole world."

Though having many attractive features, this definition is entirely inapplicable to the work carried on under the name of "civil engineering" in English-speaking countries, or under the heading of *génie civil* in France, and in its main terms it would be far more suitable to indicate the compass of the work of the third section of the Glasgow Congress—*i.e.* of "mechanical engineering"—for the essence of what is called mechanical engineering consists in the construction of machinery or mechanical devices, designed for the purpose of "directing the great sources of power in Nature" to perform automatically what in a less advanced state of civilisation is performed by animal strength. In reality, however, this definition comprises not only mechanical engineering, but is wide enough to include everything that ever has been referred to as engineering, together with all other subjects coming appropriately under the heading of technology, or applied science, in its widest sense. It would be equally applicable to the construction of steam engines, in which the expansion of water by heat—surely one of the "great sources of power in Nature"—is directed for "the use and convenience of man," and to the manufacture of chemicals or their administration by a physician, in both of which, exactly as in the previous case, some powers of Nature are directed, by those well versed in the laws controlling them, to aid mankind. Though however, this definition is unsatisfactory, as being too wide in its application, others that are proposed as an alternative are too narrow. Thus, for instance, Mr. Walter Brinckerhoff, an American, justly criticising Tredgold's definition of civil engineering as too comprehensive, suggests the phrase, "the art of changing the face of Nature for the convenience of man." This undoubtedly is more apt and fits the bulk of the operations usually included under the general term of civil engineering, but not "gas supply," and still less "telegraphy," which, though without much justification, are mentioned in the last edition of the "Encyclopædia Britannica" as being comprised under this term. Nor is there any valid reason—unless we find such reason in precedent—to confine the term "civil engineering" to operations resulting in a transformation of the face of Nature.

MR. J. D. McCORMACK, *Sec. of the Engineering Congress.*

The essential Condition of any new Definition.

It is somewhat premature, it seems to us, to establish at this moment an entirely artificial limit, such as the above, for the scope of a branch of technical science that promises to expand, like all the other branches, within the near future far beyond the most sanguine anticipations. Whatever definitions, however, ultimately may prevail for the term "engineering," be it in its widest sense or in its narrower meanings indicated by some adjective limiting its application, they must be such as make a clear distinction between what is essential and what is contingent, and utterly disregard etymology, for the art of engineering has long left behind the age when it was essentially engine-building, or when ingenuity—to accept the alternative suggested by Mr. Mansergh — was the chief qualification required of an engineer.

"Technology."

A frank adoption of the term "technology," or technological science, in place of "engineering," would, to our mind at least, be the best protection against further ambiguity; but since the adoption of this term is not likely to occur, let us at least come to an agreement regarding a rational subdivision of its subject-matter on a uniform basis, for a further analysis of the nine sub-sections above given will convince everybody that the division there adopted is absolutely without system, and it is difficult to understand how men accustomed to precision and accuracy, as engineers, for the successful performance of their duties, must be, have been able to tolerate this and similar classifications so long.

MR WM. FOULIS, PRES. INST. ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

Sub-Divisions of Engineering.

We have disposed so far of the work allotted to Sections 1, 2, 7, and 8, which, as we have seen, have a common basis, and, with the exception, perhaps, of "gas engineering," might be subsumed under the general heading of civil engineering. Among the work for the remaining five sections, that allotted to the fifth ("iron and steel") is, of course, but a subdivision of the subject-matter given to the sixth, namely, "mining," to which should be added "metallurgy," while the bulk of the problems to be discussed under the fourth heading ("naval and marine engineering") consists of such as legitimately come under the general subject with which the third section will have to deal—*i.e.* "mechanical engineering"; and the ninth division, finally—*i.e.* "electrical engineering"—owes its separate existence merely to the fact that the form of energy which is used in solving its problems has been discovered only in very recent times. As regards the problems themselves, they must be collected from the eight preceding subdivisions, and their separation from them, considering the basis of classification adopted for the other sections, is quite out of place. In fact, among the nine subdivisions placed side by side, as if together they covered the whole area of engineering, and separately represented practically

SIR W. T. LEWIS, BART., PRES. INST. OF MINING ENGINEERS.

HON. C. A. PARSONS, F.R.S., PRES. N.E. COAST INST. OF ENGINEERS AND SHIPBUILDERS.

equivalent portions, not only do some overlap each other, but most of them represent entirely different aspects of the subject of engineering. The subjects allotted to sections 1 and 2 are parts of a classification of engineering based on the results obtained by it, and would be correctly placed side by side with Aqueducts, Town-halls, Fortresses, Prisons, etc. The work allotted to Section B, *i.e.* "Mechanical Engineering," would find a legitimate place side by side with other portions of engineering classified according to means used for obtaining the desired results, such as "manual labour in building river dams," "sewage disposal by means of chemicals," etc. "Naval Architecture and Marine Engineering," given under Section 4, is a correct subdivision if we classify engineering work with reference to any specialty to which it is applied, and might have as parallels "Road Traction," "Telegraph and Telephone Installation," "Mining" (occupying, among the nine subjects referred to, the sixth place), "Refrigeration," etc. The heading "Iron and Steel," obviously meaning the mining and metallurgy of iron and steel, and mentioned fifth in order, is, of course, merely a subsection of the sixth subject, *i.e.* "Mining," and the latter ought to have been amplified by adding, as previously pointed out, the words "and Metallurgy." "Municipal Engineering," coming as the seventh division, can legitimately only form part of a classification based on the various authorities controlling the engineering operations, and might be placed in juxtaposition to "National Engineering," "Post-Office Engineering," "Board of Health Engineering," etc.

The work allotted to Section 8—*i.e.* "Gas Engineering"—should find a place side by side with the subjects given under Sections 4 and 6, while "Electrical Engineering" is a subdivision only permissible in a classification of engineering matters with reference to the power used in each special case. Its legitimate parallels would be, for instance, "Steam Engineering," "Hydraulic Engineering," "Pneumatic Engineering," etc.

Conclusions.

Unless these facts are kept in view it is not likely that people at large will ever be able to form a correct idea of the art of engineering and of those who practise it, nor will authors treating on the subject be likely to be able to give to students a lucid picture of the character and the bearing of a branch of knowledge which is second to none in importance even at this moment, and promises not only to occupy the first place among the other branches in the near future, but to hold it for many years to come. Let us now pass rapidly in review the most important of the papers read at the recent Congress at Glasgow, and try to find from their contents the actual condition of engineering matters at the present moment.

The Economic Element in Engineering.

Mr. Mansergh, in his presidential address, drew attention to one factor in the art of engineering which we have not yet alluded to, but which he correctly emphasised as one of paramount importance, namely, that of accomplishing what can be accomplished with the greatest economy. He incidentally alluded to the humorous definition of an engineer by an American, according to which an engineer is "a man who can do well for one dollar things that anybody can do somehow for double the money." Unfortunately, this allusion to money seems to have made Mr. Mansergh forget that there is a wider meaning of economy than cost-saving, and he dwells exclusively on the cash question. The economy which is to be kept in view by the engineer, however, comprises savings of a far more precious kind. His aim must be to assist in obtaining the greatest possible amount of material well-being by means of the least possible expenditure of bodily strength or useful time, and it is for this reason that what is called "mechanical engineering" forms so important a sub-section of the art, for it aims at the design of mechanical contrivances in which the forces of nature perform automatically, swiftly and efficiently, what man hitherto could perform but imperfectly, slowly, and at a wasteful expenditure of his vital strength.

MR. THOS. EVENS, PRES. SOUTH WALES INST. OF ENGINEERS.

Legislation and Engineering Enterprise.

That the good results which a country should derive from engineering enterprise are frequently prevented from making their appearance by injudicious legislation is a deplorable truth; and Mr. Mansergh, in his appeal that greater liberty should be granted in this country to those who are ready to embark upon a legitimate enterprise has our fullest sympathy; but we shall have to pass over to-day, except in rare cases, the political and social factors connected with the subject of engineering, and remain in the narrower circle of its direct action. Keeping this restriction in mind, many of the papers read in the various Sections are full of interest and of valuable suggestions. In Section A the first paper was one read by

Sir Guilford Molesworth, K.C.I.E., On the "Uganda Railway."

This paper, to some extent at least, may serve to show what we meant when we criticised Mr. Mansergh for dwelling too much on the financial aspect of the economy that should be an important element in all engineering work. Heavy sums have been expended for this daring pioneer enterprise, and the final cost is not yet counted; but whatever this cost may be, it will ultimately prove to be a mere percentage of the profits accruing from it to the British Empire. It is often not very easy to express in money-value such profits, for the mere trade returns represent but a small portion of them. The foothold obtained in an undeveloped territory by means of establishing the first lines of communication secures to the country that establishes these lines advantages quite beyond the reach of all later arrivals, as it can pick out the best locations for its own trade, and secure a prestige among the natives that stands it in good stead in case of difficulties with later competitors. A similar prestige, moreover, is established through its enterprise nearer home, and it reaps the advantages that have caused the saying, *Beati possidentes*. Add to this the effects that successful ventures of a country infallibly have upon the younger generation, strengthening their patriotic pride, and inciting them to emulation of the deeds of their predecessors when appeal is made to their patriotism, and the fact that the greatest dangers to the development of a nation are self-satisfied idleness or unwillingness to risk sacrifices when a call is made upon its citizens by those to whom they have entrusted the duty of ascertaining what is needed for the common good; and it will be realised that there are many hidden benefits that must be taken into consideration when balancing profit and expenditure. These reflections are surely necessary before the acts of those who inaugurated the building of the Uganda Railway should be criticised in the way they have been criticised. Most of us, however, will agree, after reading Sir Guilford's paper, that the energy and ingenuity shown in overcoming the enormous difficulties in the way of the construction of this railway are in them-

MR. W. E. LANGDON, PRES. INST. ELECTRICAL ENGINEERS.

MR. CHAS. MASON, PRES. OF THE SOCIETY OF ENGINEERS.

MR. W. R. HERRING, *Vice-Chairman of the Gas Section.*

selves a full equivalent of the money expended, while there is no reason for mistrusting the experts who seem to be convinced that the line, even from a financial point of view, will prove a success within a very few years.

Professor Carus Wilson's Paper on the Economy of Electricity as a Motive Power on Railways at present Driven by Steam,

Dealt with a very timely subject; the only pity is that there are yet so many persons in this country who have to be addressed in this way with reference to facts that have long since been treated on the European continent, as well as in the United States, as self-evident. Here also the cause of the wrong opinions still prevailing in Great Britain is the fact that the tangible profits—although even these are sufficient to render the speedy substitution of electricity for steam advisable—represent but a portion of the real benefits of the change. The neatness, cleanliness and convenience of electric traction and the sanitary advantages that must result from the adoption, cannot easily be expressed in terms of money without lengthy explanations which few persons would take the trouble to read, and consequently they are ignored. Our own conviction is that, expressed in terms of shillings and pounds, if all the indirect profits be counted, they represent a greater total than that resulting from passenger and freight rates, after deduction of the cost of maintenance and the redemption of the capital invested.

Mr. James Barton's Paper dealing with the Problem of Constructing a Tunnel between Scotland and Ireland,

contains very convincing arguments for the feasibility of the enterprise, arguments, however, the weight of which is more obvious to the professional engineer than to the layman; and as regards the advisability there can be hardly two opinions, but this is a feature not exactly appropriate for discussion in this place. It may be pointed out, however, that the construction of this tunnel does not offer sufficient inducement to the speculating contractor, and that this is a case in which Government initiative, or at least a considerable subsidy, appears to be well advised. It is satisfactory, therefore, to learn that Mr. Balfour appears to be inclined to bring the subject to the notice of his colleagues in the Cabinet, as soon as the question of expenditure has been somewhat more definitely answered than has been the case so far. Tunnel building has become a much simpler matter than it was at the time of constructing the Mont Cenis tunnel, and perhaps in no branch of civil engineering has progress been more rapid of late years than just in this kind of work.

The paper read in section 2 by

Mr. W. Willcocks, C.M.G., M.Inst.C.E.,

late Director-General of Reservoirs in Egypt, on

The "Irrigation in the Nile Valley

and its Future," is perhaps the most important of all, regarded as a source of information regarding the scope and progress of engineering. Civil Engineering is that branch of the art which forms the chief connecting link between the Present and the Past. In his sketch of the ancient irrigation works of Egypt, rapid though it was, the author succeeded in forcibly impressing upon his audience the fact that the magnificent enterprise of the construction of the Assuan dam and the works connected with it do but continue, restore, and amplify undertakings equally grand that were started and in great part completed more than 7,000 years ago. This, to a certain extent, invalidated a remark in Mr. Mansergh's address that civil engineering began with the Romans, and shows that there is much better reason, as Sir John Wolfe Barry remarked, for the belief of those who know Egypt, that it began in the great nursery of knowledge that bordered on the Nile. Taking into consideration, however, some of the ruins of the past found in the country between the Euphrates and Tigris, and the ancient historical records of China, we are inclined to believe that Civil Engineering had even a more remote beginning in Asia. At a first glance it might appear from this that our much

boasted progress in engineering enterprise has but a weak foundation in fact. A more careful consideration, however, shows that in the Egyptian and Assyrian engineering work there is lacking what we have called one of the most important factors, namely, that of economy in its highest sense, *i.e.* economy of human strength and time. It is a moot question, we grant, whether the ancients lacked machines, but, at all events, as their own pictorial records show, the expenditure of human physical strength in the execution of their gigantic works must have been enormous, and of time the Eastern nations have always been spendthrifts. It is, therefore, the striking progress in mechanical engineering that renders modern civil engineering superior to civil engineering in former ages. This great development in the construction of mechanical devices and labour-saving machinery, found expression during the Glasgow Congress in the fact that Section 3 was by far the largest of the nine, and required the largest premises, *i.e.* the Debating Hall of the Students' Union, for its meetings. The natural limits of a magazine article prevent us from devoting more space to the papers read than is required for a bare reference to a few among them, selected at random rather than on account of special merit; and omission, of course, does not imply an invidious distinction. Months would be required in reading these papers—more than a hundred in number—with sufficient care to permit us to discriminate between them, so that we must be satisfied with the selection of a few remarks that struck us as interesting during a very rapid perusal of this wealth of engineering literature. The paper of the

Hon. Charles A. Parsons, F.R.S., on "Steam Turbines for Driving Dynamos,"

read in Section 3, has a kind of internal connection with the paper of Mr. W. Willcocks, just discussed by us, for its subject matter is also linked to the Past by the fact that the turbine is one of the few mechanical contrivances that was known to the ancient Greeks, though the turbines of Mr. Parsons and their practical efficiency, established by the severest tests, is hardly commensurable with the toy of Hero of Alexandria. Professor Schroeter, one of the German visitors, paid a high tribute to the inventor and the excellent results obtained by him during experiments made with a 1,250-kilo-watt turbo-alternator on behalf of the city of Elberfeld, and indirectly supported the remarks made in the September issue of FEILDEN'S MAGAZINE to the effect that Continental engineering is not so solidly founded as its eulogists are in the habit of maintaining, by declaring that this turbine showed a higher economy than an exactly corresponding set of triple-expansion engines built by Messrs. Sulzer.

The discussion following the reading of Mr. Parsons' paper must have been highly gratifying to the author, and the advantages derived from a meeting between our own and foreign engineers for the exchange of opinions on important subjects of common interest was clearly demonstrated by it, as well as by the paper of

Mr. Gisbert Kapp, of Berlin, on "The Rating and Testing of Electrical Machinery."

This paper also led to an interesting discussion, which incidentally showed that, as regards papers on more or less complicated subjects, a previous reading is almost a duty on the part of those who offer criticism, as listening to the author rarely suffices for the weighing of its arguments; and, besides, some of the most important points are often dealt with in the "appendix," which is usually omitted during the oral delivery of the paper.

The progress made in Naval Architecture was interestingly described by

Sir Nathaniel Barnaby,

one of our highest authorities on the subject, in a paper entitled

The Chief Characteristics of the Development of the Nineteenth Century.

Notwithstanding the restricted compass of a twenty-minutes' paper, Sir Nathaniel gave a very lucid explanation of the most important turning points in the modern history of shipbuilding. He pointed out that the substitution of iron for wood as building material rendered it pos-

sible to add considerably to the length of ships and to equip them with the gigantic propelling machinery used in modern times. The characteristic point of the development during the first part of last century was the gradual differentiation in the types of ships for commerce and for war. Characteristically enough, it was a progressive feature, *i.e.* the use of iron in the building of the merchant vessels, that lost them the good opinion of the Lords of War, who, with their usual conservative stubbornness, insisted that iron-built ships could never be able to fight, and they withdrew all provisions for arming the merchant vessels, abandoning at the same time the military control of these ships. The rift was increased by the use of side armour on the war vessels, and the two types drifted more and more apart until the tendency to surrender the innovation made itself felt in naval circles during the last twenty-five years, and at present both war and merchant vessels are being built of the same materials and with equal speeds, while the modern commercial type lends itself perfectly for naval equipment and armament and possesses the advantage of greater average speeds. Sir Nathaniel Barnaby's paper, and the discussion following it, clearly demonstrated, among other matters, that naval engineering is by no means the least important sub-section of the art, though the building of war-vessels contains, only in a somewhat remote way, what to some critics appears to be a very essential factor in high-class engineering, namely, the utilisation of the forces of Nature "for the convenience of mankind."

The Iron and Steel Institute.

Section 5, to which the engineering problems connected with the metallurgy of "Iron and Steel" were allotted, resolved itself, on assembling, into the ordinary summer meeting of the Iron and Steel Institute, this being its third meeting in the city of Glasgow. A very large audience listened to the many interesting papers submitted to them, the bulk of which will soon appear in print and bring up to date the valuable and useful literature published under the auspices of the Institute, which, even at present, comprises 30,000 pages issued since its inception. But, then, this is the "Iron Age," and to iron modern engineering owes many of its greatest triumphs. After a short address by the President, Mr. William Whitwell, a summary of a paper prepared by the West of Scotland Iron and Steel Institute was read by Mr. Walter Dixon. This paper consists of three parts. The first of these deals with pig-iron, and was composed by Mr. Henry Burnby, of Cottness, who traced the development of the industry since the two previous meetings in 1872 and 1885, and gave an account of the ore resources and the production of by-products from the furnace. The second, for which Mr. Wm. Wylie, of Coatbridge, is responsible, is devoted to malleable iron, and contains the interesting information that there has been no falling off in the production of Scotland, as compared with the output 20 years ago, though in other districts the industry is dying. The third part, finally, written by Mr. Henry Archibald, of the Dalzell Steel Works, refers to the production of steel, which, since 1873, seems to have been almost entirely produced in the acid open-hearth process, though there are indications that in the future basic-lined furnaces will come into use.

A very interesting paper on the "Variations of Carbon and Phosphorus in Steel Billets," by Mr. Wahlberg, of Stockholm, was, at the author's request, read in abstract by the secretary. This paper refers to researches undertaken to establish, first, the limits of variation of carbon and phosphorus as found in soft, medium, hard, and very hard steel, which has been cast at a normal temperature into 10-in. to 12-in. ingots and then rolled into 4-in. billets, either directly or after cooling down and reheating once; whether, and to what extent, chemical analyses of absolutely identical samples vary in the results as to percentage of carbon and phosphorus when made by different chemists.

The consideration of the results obtained, however, must be deferred until the next issue, as must also the references to other papers read.

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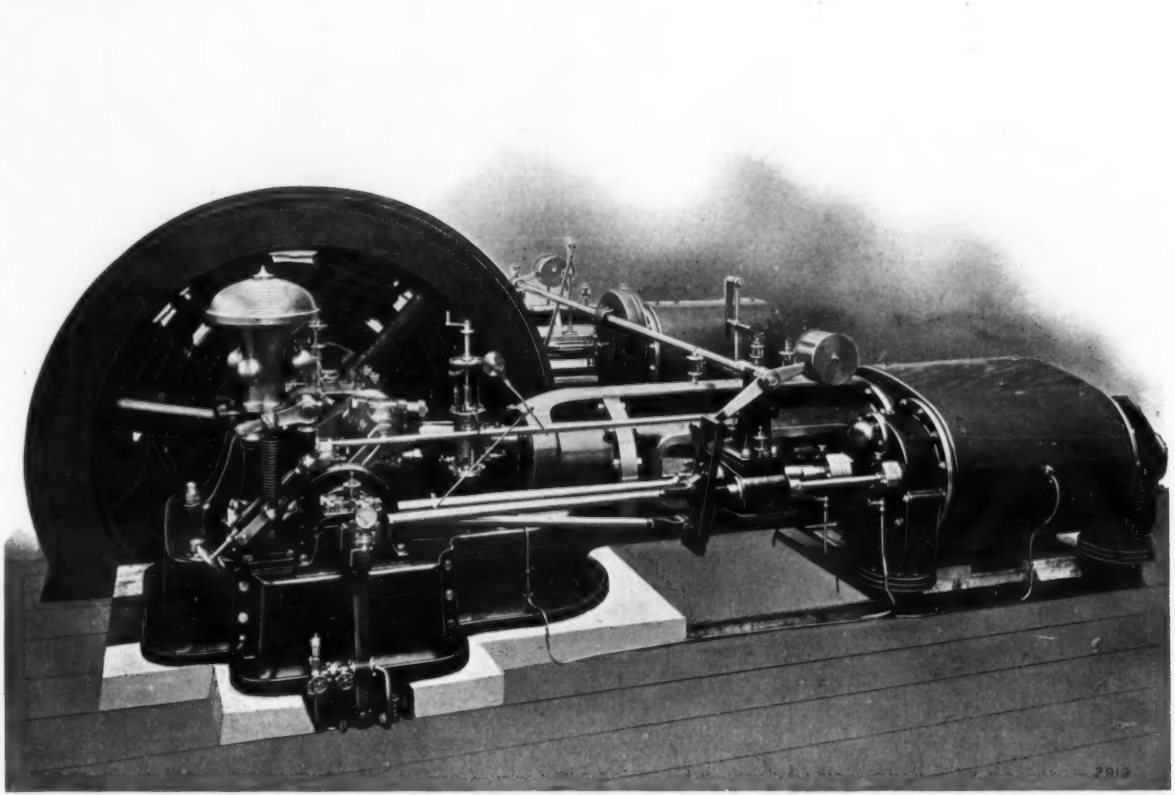
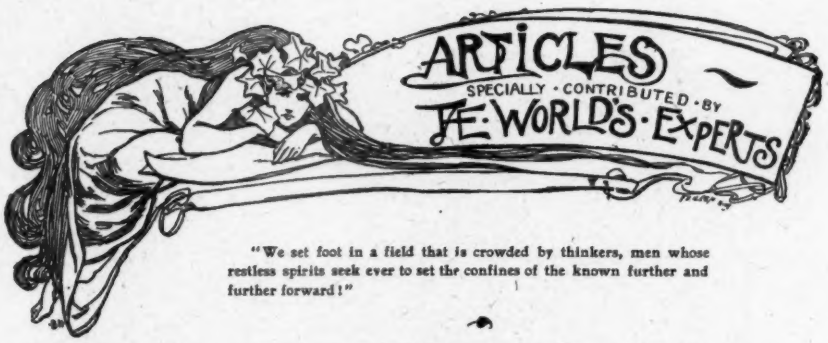


DAVEY-PAXMAN CROSS COMPOUND HORIZONTAL ENGINE AND ELECTRIC CONSTRUCTION CO. DYNAMO AT THE GLASGOW EXHIBITION.

See page 343



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

Alternating Current Motors.

By ALFRED HAY, D.Sc., M.Inst.E.E.

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THE Frankfort Electrical Exhibition of 1891 marks an important era in the history of electrical engineering. The possibilities of a new system of power transmission and distribution, known as the "Drehstrom," or rotary current system, were then first brought prominently before the public, and there is no doubt that the subsequent rapid development of polyphase systems was largely due to the powerful impulse given to it by the Frankfort Exhibition.

The experiment of transmitting about 100 h.p. a distance of over 100 miles along three copper wires, each of which was only 4 millimetres (·157 ins.) in diameter, at the high pressure of 8,000 volts, was indeed, at that time, sufficiently startling to attract general attention and interest. The success of the experiment had not a little to do with the establishment of the numerous long-distance power-transmission schemes which have since come into existence.

The Lauffen-Frankfort experiment is mainly interesting as marking the advent of a new type of alternate-current motor—the so-called "induction motor." Power transmission by alternate currents was, however, not unknown before the date of the Frankfort Exhibition; only the motors used up to that time were of a different type.

Considering the number of central stations working on the alternate-current system, and considering also the rapidity with which the use of electro-motors is extending, as the public are beginning to awaken to the many advantages presented by them, it may not be without interest to consider briefly the main characteristics of the various types of alternate-current motors now in existence.

It is known that any ordinary continuous-current motor will run in the same direction irrespective of the direction of the current. If, therefore, we imagine such a motor to be supplied with an alternating instead of a continuous current, each of the impulses received by the motor will tend to drive it in the same direction, and the motor will go on running. Practically, however, the use of such motors presents formidable difficulties. An alternating current gives rise to an alternating magnetic field, and this in its turn produces an e.m.f. in the exciting coil, which tends to oppose changes in the current. The results are: (1) that the current is very much smaller than it would be if there were no alternating field; and (2) that the current lags behind the

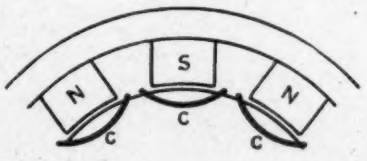


FIG. 1.

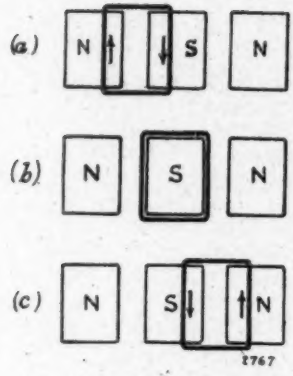


FIG. 2.

potential difference as regards phase. In a shunt-wound motor, owing to the amount of "lag" being different for the armature and field currents, these two currents do not reach their maxima values simultaneously, and the torque is thereby greatly weakened. For this reason, the series winding is the only one practically used in this class of motor. Again, it is impossible to use solid field cores in the case of such motors, for the alternating magnetic flux in a solid core would give rise to powerful currents in the core, and the effect of such currents would be to practically shield the interior of the core, and to produce a surface-concentration of magnetism, the magnetic flux being confined to a comparatively thin layer —being "skin-deep" only. It is therefore necessary to laminate the field, which, of course, renders the construction of the machine more costly. There are the following further difficulties inseparably connected with this type of motor: on account of the rapidly alternating magnetic flux through the armature core, each coil as it undergoes short-circuit becomes the seat of strong induced currents, and sparking is very liable to occur at the instant of open-circuiting; and, on account of the considerable lag of current behind the potential difference—especially under light loads—the ratio of the true watts to the product of volts and amperes, or the "power-factor," is low.

When one considers all the defects enumerated above, it is hardly surprising to find that such laminated field motors are only made in very small sizes, and for low frequencies, and might almost be left out of account so far as their practical importance is concerned. The attempt to adapt ordinary continuous-current motors for work on alternate-current circuits has not proved a success, either electrically or commercially, and wherever motors of large output are required, machines specially built for use with alternate currents are employed.

Alternate-current motors may be classed under two heads, viz.:—

1. Synchronous motors.
2. Non-synchronous motors.

A synchronous motor is one whose speed bears a definite constant ratio to the frequency of the alternating current with which it is supplied. This ratio depends solely on the number of poles

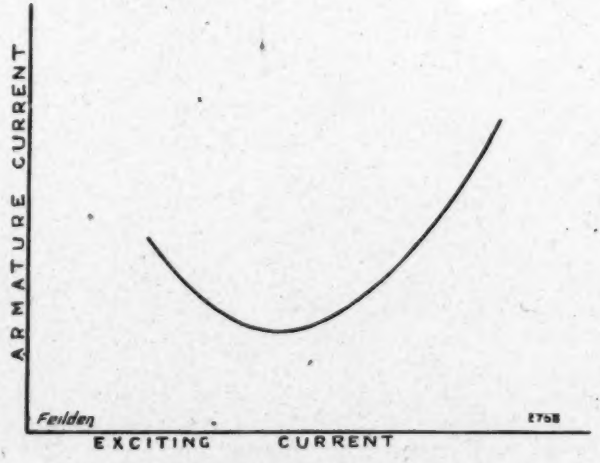


FIG. 3.

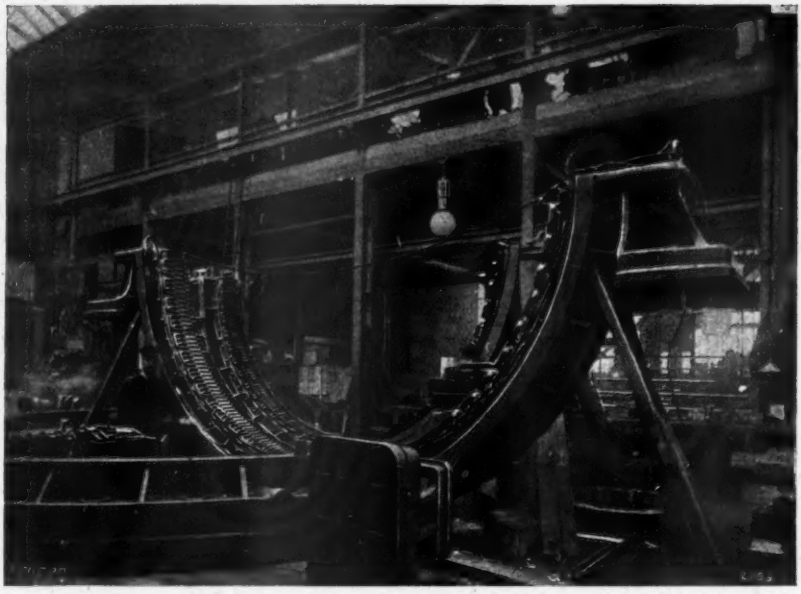


FIG. 4.—VIEW OF 300 K.W. TWO-PHASE GENERATOR IN COURSE OF CONSTRUCTION FOR THE FULHAM VESTRY AT THE WORKS OF THE GENERAL ELECTRIC CO., LTD.

in the motor field. The speed at which such a motor runs is termed its speed of synchronism, or its *synchronous speed.* The main characteristic of a synchronous motor is, that it is incapable of running at any other speed than that of synchronism.

A non-synchronous motor is, on the other hand, a motor whose speed varies with the load, and therefore bears no definite ratio to the frequency of the supply current.

One of the main disadvantages of a synchronous motor is that it is not self-starting; while a non-synchronous motor is capable of starting from rest under load.

We shall now briefly review the theory and consider the practical construction of these two types of motor, pointing out the peculiarities of each type.

I. SYNCHRONOUS MOTORS.

Any ordinary alternate-current generator may be used as a synchronous motor. The typical synchronous motor would therefore consist, as shown in Fig. 1, of a series of polar projections NSN arranged round the circumference of a circle, and a movable system of conductors CCC conveying alternating currents. The essential feature of a synchronous motor is the combination of a constant, separately excited field, with a system of conductors carrying alternating currents. The reaction between the constant field and the alternating currents furnishes the driving torque of the motor. It is immaterial which of the two systems is fixed and which is movable.

The principle underlying the action of such a synchronous motor will be readily understood by reference to Fig. 2, in which *a*, *b*, and *c* refer to three different positions of one of the armature coils In position *a*, the current flowing in the coil has a direction such that the coil tends to move from left to right. In position *b*, the current is supposed to have diminished to nothing. If now the coil is still to be driven by the current beyond

the position *b*, then it is obvious that a reversal of current must take place as the coil passes this position, in which case the force acting on the coil will tend to move it in the same direction. By properly timing the current impulses, a unidirectional driving torque is obtained. It is evident that, when the motor is at rest, it cannot be started by sending an alternating current through the armature. It must first be run up to a speed such that the alternating current waves will be properly timed with regard to the position of the armature relatively to the pole-pieces. It will be further noted that the driving torque is not continuous, but made up of a series of impulses. If we suppose that the reversal of current takes place in a position other than *b*, then, instead of a succession of impulses all of which tend to move the coil one way, we get alternately positive and negative impulses. If the torque is to remain unaltered, then the algebraical sum of the various impulses must be the same as before; and this can evidently happen only by an increase of current, and therefore increased loss by heating. From this it is evident that the same torque may be obtained with widely different armature currents. The value of the armature current depends on the excitation, and the nature of the relation connecting the two is shown by the curve in Fig. 3. The lowest point of this curve corresponds to the highest power-factor, and hence to the most economical conditions of working.

II. NON-SYNCHRONOUS MOTORS.

Although the theory and principles of design of this class of motor are somewhat complicated, it is by no means difficult to gain a clear general idea as to how the motor acts. The action of such a motor is, in fact, only one illustration of a very general law which governs many physical phenomena. To take one or two simple mechanical illustrations. Suppose a body originally at rest to be set in motion; so long as acceleration is taking place, re-

FIG. 5.—VIEW OF TURBINE-DRIVEN POLYPHASE GENERATORS BUILT BY THE FULLER-WENSTRÖM CO.

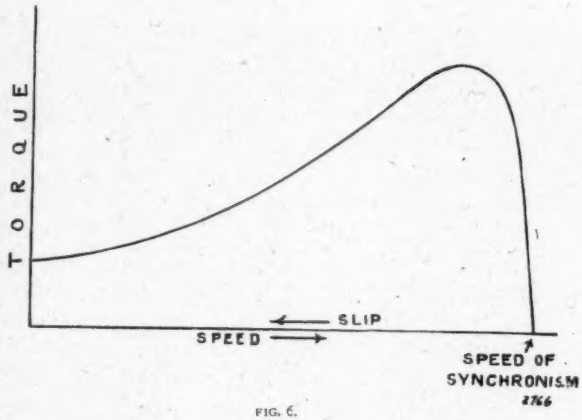


FIG. 6.

sistance be will offered to the motion; when the motion becomes steady, no further resistance (leaving out of account friction, etc.) will be encountered; but if we now attempt to arrest the motion of the body, a resisting force will once more come into existence. In other words, any change of motion is accompanied by the appearance of a force which tends to resist the change. A similar result holds for friction: whichever way a body in contact with a rough surface is moved, friction always resists changes of position, just as inertia resists changes of motion.

Passing now to the electro-magnetic case, we find that *every closed conducting circuit resists changes in the magnetic flux through it*; the resistance is due to the induction of currents in the conducting mass by the varying magnetic flux. This important principle, on which the action of all modern non-synchronous motors depends, finds a good illustration in some very old classical experiments. Arago caused a horizontal disc of copper to spin underneath a pivoted magnetic needle, and found that the needle was always deflected in the direction of rotation, showing that relative motion of the disc and needle was resisted. Babbage and Herschel pivoted a copper disc, and spun a magnet underneath it; again the copper disc was found to follow the motion of the magnet.

Imagine now a laminated cylindrical core of iron mounted on a shaft, and having a number of conductors embedded in it, and connected up in such a manner as to form several closed circuits. Let such an armature (an ordinary Gramme-wound armature, but having each coil short-circuited on itself instead of connected to a commutator, would do) be placed between the poles of a powerful electro-magnet, and let the latter be set in rotation. This is merely a repetition of Babbage and Herschel's experiment on a large scale, and we know what will happen: the currents induced in the conducting paths surrounding the laminated core will give rise to forces which will cause it to follow the rotation of the magnet.

From this it is evident that an armature with short-circuited coils may be made to spin round by placing it in a *rotating magnetic field*.

In the experiment described above, a rotating field was obtained by the rotation of an electro-magnet. In a modern *induction* motor (so called because its motion is due to the *induction* of currents in one set of its windings), a rotating field is obtained *without any mechanical rotation of the mass producing the field*.

This result is accomplished by the use of two or three alternating currents, which *differ in phase*, and the scientific principles underlying the production of a rotating field by means of such currents were first clearly stated by the late Professor Galileo Ferraris.

Imagine a hollow laminated cylinder wound with two coils arranged at the extremities of a diameter of the cylinder, and coupled up so that when a current is sent through the coils, a magnetic field is produced across the interior of the laminated cylinder. If the current is an alternating one, a simple alternating field will result. The field intensity at any

point might be represented by a line one extremity of which is fixed, while the other moves according to the simple harmonic law. Suppose next that another pair of coils is arranged on the same cylinder, and is similarly supplied with an alternating current of the same frequency, but differing by a quarter-period in phase from the first current. The field-intensity due to this second current may also be represented by a simple harmonic motion. But two simple harmonic motions along two mutually perpendicular straight lines are known to compound into uniform circular motion if the phase-difference amounts to a quarter-period. We thus see that by having two independent exciting circuits, supplied with two currents between which there is a phase-difference of a quarter-period, a rotating magnetic field may be produced in the interior of the hollow laminated cylinder. Such a system of currents is termed a *two-phase system.*

Similarly it may be shown that by the use of three exciting circuits, spaced 120 degs. apart, and supplied with three currents between which there are phase differences of 120 degs., or one-third of a period, a rotating magnetic field may be produced in the interior of the laminated cylinder. Such a system of three currents is termed a *three-phase system.*

If now we introduce into the interior of the cylinder our short-circuited armature, we obtain a *polyphase induction motor.*

A two-phase system of currents requires four wires for its transmission (two wires for each circuit). A three-phase system of currents may be, and commonly is, transmitted along three wires only, the three circuits of the motor not being independent, but linked together to form either a Y, or a Δ, and the three-line wires being connected to the free ends of the Y-limbs or the angular points of the Δ respectively. The possibility of using three wires only instead of six (as would be the case if the circuits were kept independent) is due to the fact that in a system of three-phase currents the algebraical sum of the three currents at any instant is zero.

Polyphase currents are produced by alternators whose armatures are provided with as many windings as there are

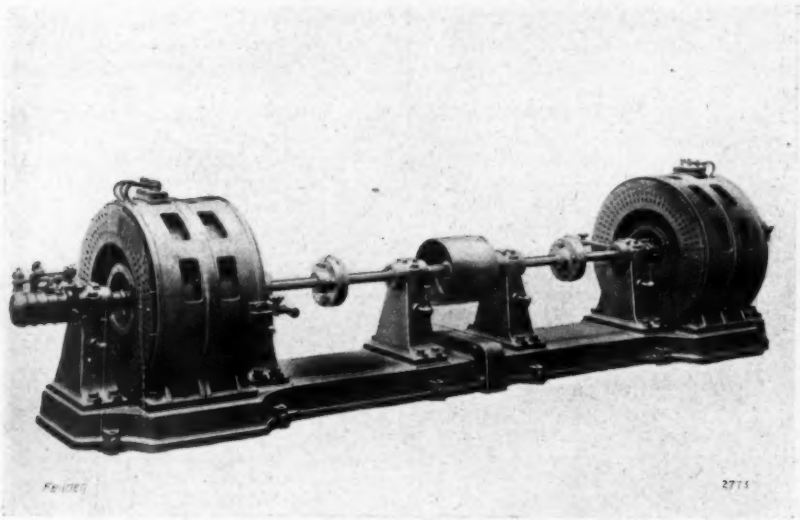
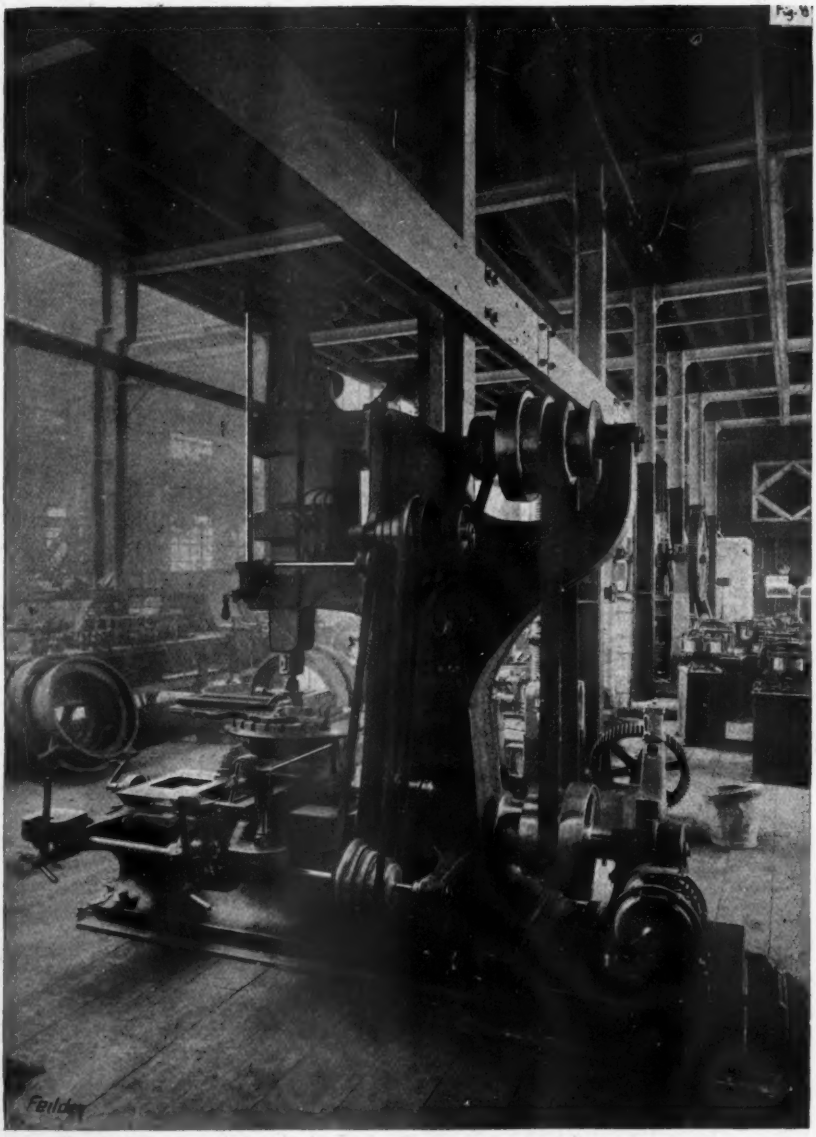


FIG. 7.—TWO 36 B.H.P. THREE-PHASE MOTORS COMPLETE.



[FIG. 8.—1 H.P. THREE-PHASE MOTOR DRIVING VERTICAL MILLING MACHINE, GENERAL ELECTRIC CO., LTD.'S WORKS, MANCHESTER

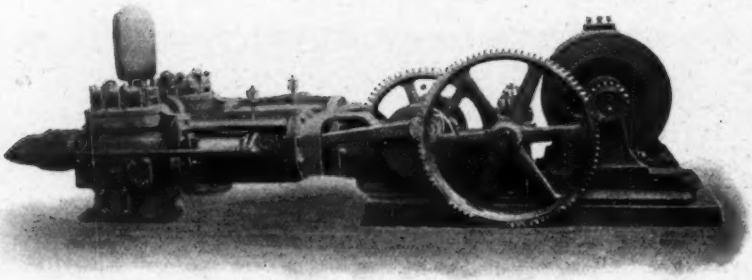


FIG. 9.—9 H.P. THREE-PHASE MOTOR GEARED TO A DUPLEX PUMP: SUPPLIED TO CONSOLIDATED GOLDFIELDS OF SOUTH AFRICA, LTD.

phases, the relative positions of the windings being determined by the required phase differences. It may be at once stated that any polyphase generator may be used as a *synchronous motor*. Fig. 4 is a view of a 300-kilowatt two-phase generator in course of construction for the Fulham Vestry by the General Electric Co., Ltd., of London and Manchester, by whose courtesy we are able to give this and a number of succeeding photographs. The large semi-circular structure seen in this photograph is one half of the stationary armature, and the alternation of the two sets of coils belonging to the two circuits is clearly visible. The field-magnet for this machine is excited by a single fixed exciting coil, and has a number of polar projections which sweep across the inner surface of the armature core-discs. Fig. 5 is a view of some large turbine-driven polyphase generators by the Fuller-Wenström Co.

The polyphase induction motor consists, as we have seen, of a *primary* or *inducing* winding embedded in a laminated core, and a *secondary* or *induced* winding similarly embedded. In most cases, the inducing winding is stationary, and, with its core, forms the *stator* or stationary part of the motor; while the induced winding is embedded in the rotating core, and forms the *rotor* of the machine. The inducing winding consists, as already explained, of a number of coils so arranged as to give rise to a rotating field. Very frequently, the inducing winding is supplied at a high voltage, and generally consists of coils having a large number of turns. The induced winding, on the other hand, consists of relatively few turns, and the method of coupling up the conductors varies in different types of machines. One of the commonest forms of induced winding is that known as a *squirrel-cage* winding, so called from its resemblance to a squirrel-cage: this consists of a series of stout rods of copper surrounded by thin tubes of insulating material and embedded in the rotor core, with a ring of copper connecting the bars or rods at each end. In another form of winding we have simply a set of coils, each of which is independently short-circuited on itself. In other cases, again, the winding is similar to that which would be used if the rotor were required to act as the armature of a generator: it consists of three circuits, spaced so that the electro-motive forces induced in them have phase-differences of 120 degs.; the three circuits are Y- or star-connected, and the free ends are attached to three slip-rings. The great advantage of a three-phase winding for the rotor is that a starting resistance may be introduced, by means of the slip-rings, into the rotor circuits, and so an increase of starting-torque be brought about.

Since the resistance of the rotor circuits is very low, a very small e.m.f. will suffice to produce large currents in them. Hence under normal working conditions a very slight difference—amounting to some 5 per cent. at full load, but varying with the size of the motor—in the speeds of the rotating field produced by the stator and of the rotor is sufficient to give rise to the necessary current. In reality, therefore,

although induction motors do not run synchronously, yet their speed, within the ordinary limits of load, varies very little, and is always not far removed from the speed of synchronism. An induction motor in this respect closely resembles an ordinary continuous-current shunt-wound motor.

Let us now suppose that the load on an induction motor is steadily increased beyond its normal full load. As the motor must exert a steadily increasing torque, there must be a gradual increase in the rotor current, and therefore in the *slip* of the rotor (*i.e.* its speed *relatively* to the rotating field). So long as the slip is small, the resistance of the rotor windings is the only quantity which need be considered in determining the current and the torque. But as the slip, and with it the frequency of the rotor currents, increases, the magnetic flux produced by these currents begins to exert an appreciable effect, which consists in (*a*) reducing the magnitude of the current and (*b*) causing it to lag behind the e.m.f. as regards phase. Now, since a conductor, or group of conductors, when in the position of maximum e.m.f., is also in the best position for producing torque, it follows that any phase displacement of the current relatively to the e.m.f. results in a decrease of torque. On account of increasing phase displacement with increase of slip, the torque of the motor increases but slowly with the slip beyond a certain point; it reaches a maximum, and then actually decreases, as shown in Fig. 6, which is a typical torque-speed curve for an induction motor.

By the insertion of a resistance into the rotor circuits at starting, the magnitude of the rotor currents is reduced; but at the same time these are brought much more nearly into phase with the e.m.f. The latter effect is of much greater importance than the former, and a very large increase in the starting torque is obtained. The starting resistance is gradually cut out as the motor gains speed.

The air-gap between the stator and rotor is made as small as possible, consistently with safety from a mechanical point of view. A motor with a large air-gap would have a low power-factor, a relatively small output, poor regulation and low efficiency.

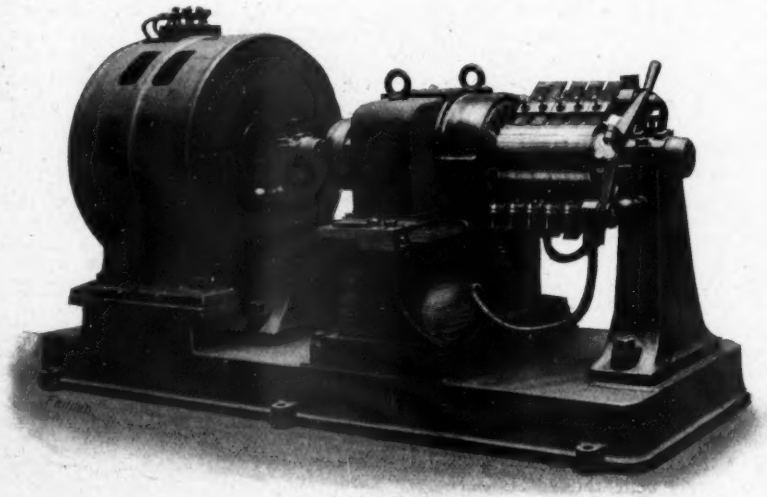


FIG. 10.—6 H.P. THREE-PHASE MOTOR COUPLED TO PLATING DYNAMO, 300 AMPS., 15 VOLTS: SUPPLIED TO YORK GOLD MINING CO., SOUTH AFRICA.

Probably the earliest instance of the use of polyphase power distribution in England is to be found in the three-phase plant installed at Bootle, Liverpool, by the General Electric Company, Ltd., of London and Manchester, for the Liverpool Grain Storage and Transit Company. Three-phase induction motors are used for working the grain elevators and conveyers. The plant has now been in operation for over four years, and has given every satisfaction.

Fig. 7 shows two 36 b.h.p. General Electric Co.'s three-phase motors coupled to the same shaft. In Fig. 8 is shown one of the vertical milling machines in the General Electric Co.'s works at Manchester, driven by a 1 b.h.p. three-phase motor; it will be noticed that the motor, seen to the extreme right of the illustration, occupies very little space. In the distance, also to the right, are seen a number of starting resistances for induction motors.

Fig. 9 shows a 9 h.p. three-phase motor geared to a duplex pump; while in Fig. 10 is seen a 6 h.p. motor driving a plating dynamo.

Besides three-phase induction motors, single-phase motors of this type are also largely used. The action of such a single-phase motor is, perhaps, most easily understood by supposing the simple alternating field produced by the single-phase current replaced by two rotating fields. So long as the motor is at rest, the torques produced by the two oppositely rotating fields on the rotor are equal and opposite, and there is no resultant torque. But if a certain initial speed be impressed on the rotor, the torque due to the field having the same direction of rotation as the rotor is increased, while that due to the oppositely rotating field is decreased, a resultant torque being thus produced. A single-phase induction motor is not self-starting (without special arrangements for this purpose), and has a lower power-factor and lower efficiency than a polyphase motor.

In order to render single-phase motors self-starting, it is usual to provide the stator with an additional "starting" winding, which consists of a different number of turns from that in the "running" winding. The currents in the two windings having a certain phase-difference, a rotating field is produced which enables the motor to start. Even then, however, the starting-torque is not always very powerful, and in such cases it is convenient to provide a fast and loose pulley, so that the motor can be started light and the load thrown on when it has run up to speed and is capable of exerting a powerful torque.

Fig. 11 shows a 25 b.h.p. Langdon-Davies single-phase motor. This motor is provided with a starting winding which is cut out as soon as the motor has run up to speed.

Polyphase transmission systems have been almost invariably used on the Continent and in the United States for the transmission over long distances of considerable amounts of power. But opinions are still divided as to the relative merits of the polyphase and single-phase systems. Single-phase induction motors have been greatly improved within recent years, and may in the near future approach polyphase

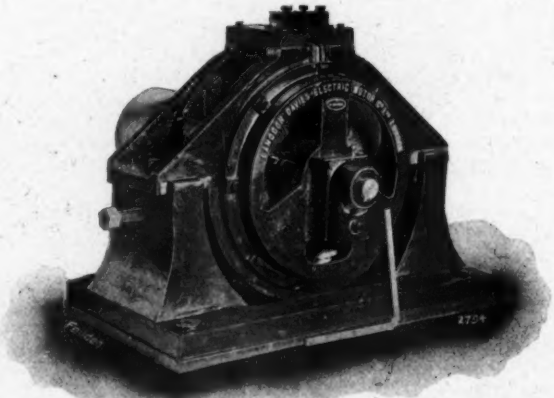
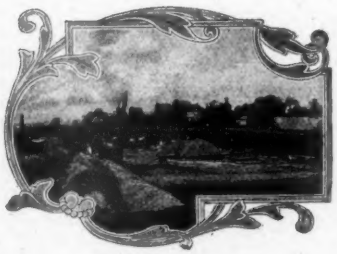


FIG. 11.—25 B.H.P. LANGDON-DAVIES SINGLE-PHASE MOTOR.

motors as regards starting-torque, power, and efficiency. But whatever the opinions of individual engineers may be, certain it is that up to the present polyphase systems have held their own in practice for power transmission and distribution, and are likely to do so for some time to come. The era when small power users will, almost without exception, obtain their power from electric motors is fast approaching, and in this development of electrical power distribution the polyphase induction motor, with its large starting-torque, high efficiency, and extreme simplicity of construction, is likely to play no inconsiderable part.

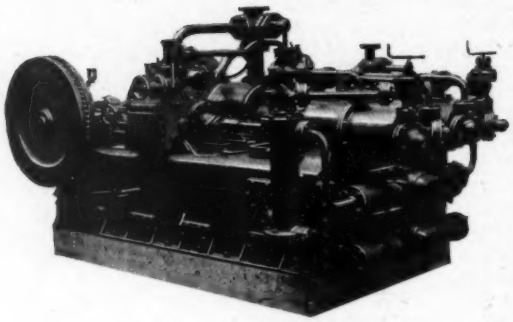
Alfred Hay



Modern Ice-Making and Refrigerating Plants.

By A. C. LEMPRIERE BACK, M.I.Mech.E.

(Continued from page 147.)



LINDE DUPLEX MARINE TYPE COMPRESSOR.

THE regulator is merely a throttle-valve placed in the connecting pipe between the condenser and evaporator coils. Its function is to enable any difference of pressure and temperature to be maintained between the gas in the condenser and refrigerator—within limits, of course.

The evaporator is exactly similar to the condenser in construction, but instead of a water circulation round the coils there is a circulation of brine. The function of the evaporator is to enable the gas from the condenser to re-evaporate by absorption of heat from the brine. The casing round the evaporator is lagged, to prevent heat penetrating from the outside as far as practicable.

By the help of the diagram, let us follow the machine in its working.

We assume that the condenser and evaporator have been sufficiently charged with the refrigerating agent, or particular gas to be used.

The regulator will be wide open, and the pressures and temperatures of the gas in refrigerator and condenser will be the same, and unless the machine has been working lately the brine will be approximately at the same temperature as the water. It is the brine we want to abstract heat from. We now start the compressor working. It will draw gas from the evaporator and discharge it into the condenser. But as fast as the gas passes the compressor it will also pass the regulator, and there will in consequence be only the very slightly higher pressure in the condenser, due to the friction of the gas in the piping. The machine has not yet done any useful cooling work. We now proceed to "regulate" the machine to do its proper cooling work, and to do this we have to close down the throttle-valve, but only partially, so as to throttle the gas back and prevent it escaping so freely from the condenser to the evaporator. It will be seen that the effect of this will be at once to reduce the pressure in the evaporator and increase it in the condenser. For the compressor will now be drawing gas from the evaporator faster than the regulator will permit gas flowing from the condenser to the evaporator, and this reduction of pressure in the evaporator and increase of pressure in the condenser will continue until such a difference of pressure is produced between the two that the quantity of gas passing the regulator from the condenser balances the quantity drawn by the compressor from the evaporator; and thus, by opening or closing the regulator, any desired difference of pressure can be maintained so long as the compressor is kept working. But the point to specially notice is that, by reducing the pressure in the evaporator and increasing it in the condenser, the temperature is correspondingly reduced in the evaporator and in-

creased in the condenser according to the well-known law $V \propto \frac{T}{P}$

The regulator is closed gradually until the gas in the evaporator coils becomes 10 to 15 degs. Fahr. *below* the temperature of the brine. If the machine is then fully charged, the temperature of the gas in the condenser will be from 5 degs. to 10 degs. Fahr. *above* the temperature of the cooling water.

It will be readily seen that, working under these conditions, the gas will absorb heat from the brine and deliver it to the water, and in this way :

The gas in the evaporator being at a lower temperature than the brine by conduction through the coils, absorbs heat from the brine. The compressor receives this heat in the gas, and raises it by compression to a higher level of temperature in the condenser, where the water, by conduction, receives it and carries it away. If there is a plentiful supply of water, it will run to waste by a drain, and carry the heat with it, but if the town supply has to be used and paid for, a re-cooler must be used, of which there are several forms, and the water is then carried to the roof of the building, and a large surface is exposed to the air outside, and the air then becomes the recipient of the heat. The heat still exists, but we have removed it, and got rid of it so far as we are concerned.

To complete this heat cycle, we have to note how the brine receives its supply of heat. The brine receives heat from the water which is to be made into ice and from the air and goods in the cold stores.

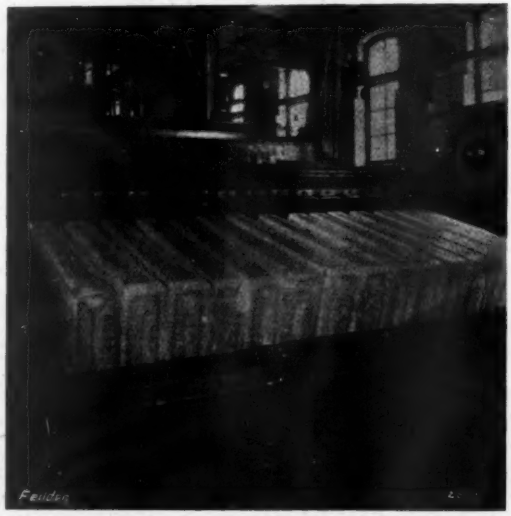
The brine is in a closed circuit, and merely acts as a medium for conveying the heat from the ice-water and store-rooms to the evaporator, picking up the heat by conduction from the ice-cans and cells and the pipe grids in the store-rooms on its continuous circuit, and discharging it in the evaporator.

The brine is never stopped in its course, but, like the gas, and the water when a re-cooler is used, is kept moving in a continuous and closed circuit. Reference to the arrows on the diagram on page 139 will show the course the heat takes in travelling from inside to outside the building.

(1) The brine collects the "heat" in ice-tanks or stores.
(2) Conveys it to the evaporator.
(3) In the evaporator it is transferred from the brine to the gas.
(4) It is compressed and raised to a high level of temperature.
(5) It is transferred in the condenser from the gas to the water.
(6) It is transferred from the water spray to the outside atmosphere.

The whole process may be called one of collection and delivery. Heat is collected inside the building and conveyed to the outside. There is no annihilation of heat, and can be none, but only removal. This is what we call refrigeration.

In order to keep the process simple and to be easily followed, I have purposely left out, up to the present, the most important factor of economy in the



30 CWT. OF CAN ICE.

60 TONS OF CELL ICE.

working of these vapour-compression machines.

It will be seen that the amount of cooling the machine will do is strictly in proportion to the amount of heat we can get rid of in the condenser. So far as I have described the process at present, a machine of this construction, using air as a refrigerant, would work doing actual refrigeration, but only a fraction of the amount that would be accomplished when using ammonia, carbonic acid or sulphuric acid gas. For not only do these latter agents give out the heat due to compression, but the far greater quantity due to liquefaction. Under the influence of pressure in the condenser and the cooling effect of the water these gases, as they reach the bottom of the coils, "change state" and become liquefied, and in doing so give up their "latent heat." And before the refrigerant has reached the regulator it is in a liquid form and passes as a liquid into the evaporator. Before this liquid can again become a gas under the lesser pressure in the evaporator, it must take up its latent heat, and this the brine supplies. The brine, already at a temperature of 15 degs. to 20 degs. Fahr. only, has to supply heat to boil away the gas, just in the same way that the furnace of a steam boiler supplies heat to boil the water into steam, with the result that the brine is still further cooled. It is in this process of liquefaction that the remarkable efficiency of the vapour-compression machine consists.

The compression cold air machine is still useful in certain cases for small powers, but the coal consumption required for driving these machines is as much as five times more than is required for the modern refrigerator.

The discovery of refrigeration by the liquefying process is one of scientific discovery, and not one of experiment only. We hear much of liquid air just now, but the enormous pressures and extremely low temperatures required in the liquefaction of air, places it beyond the possibilities of practical science and engineering to use it as an agent for ordinary commercial refrigeration, otherwise we might expect another revolution in mechanical refrigeration. There is yet a third quantity of heat to be disposed of in the condenser of the vapour-compression machine, and this is the heat equivalent of the force required to compress the gas. This is against the machine, since it is generated in the gas at each stroke of the compressor. The quantity will be proportional to the power required to drive the machine, namely, for every foot pound, $\frac{1}{772}$ of a thermal unit Fahrenheit.

It will be noticed that the gas and brine are each confined to their own closed circuit and that there is no need for a fresh charge at any time. The slight leakage from joints and glands, etc., only has to be made up from time to time, and with the water there is very little waste when a re-cooler or evaporative condenser is used. Some evaporation takes place during cooling in contact with the outside air.

The chief item of expense from a commercial point of view is the coal consumption required in driving the plant, so far as store material is concerned.

As to the method of driving these compressors, all ordinary forms have been used: gearing, belt driving, and direct steam driving.

Gearing is very seldom used, and is only useful in saving space in place of belt driving.

Plants requiring 20 to 40 h.p. can be effectively driven by gas engines through belts, the gas engine using what is known as producer gas, a gas of inferior quality to ordinary town gas, and is made on the premises. To compete commercially with this producer gas, made from coal costing 16*s.* per ton at the works, town gas would have to be supplied at 10*d.* to 1*s.* per 1,000 feet. One horse-power per hour indicated can be obtained for less than one pound of coal, but the coal has to be special anthracite (or good coke), and the cost of this fuel in the particular district must be considered; also the extra power required to drive the gas engine itself, and the loss of power occasioned by driving through belts, and the wear and tear of the same, as well as the extra oil consumption, before we can determine the net gain, if any, due to a less fuel consumption as compared with steam driving.

The loss of power and wear and tear of belts in driving with a gas engine is very considerable. The piston and bearing friction is large, and the belts suffer from the constant shocks due to a single impulse every other revolution or less, whilst with a single-crank steam engine we have four impulses every two revolutions for the same power, and these not in the form of an explosion. The gas engine is an interesting study from the point of thermal efficiency, but for its perfection mechanically it is very far inferior to the steam engine, and this becomes a serious consideration when continuous running for long periods is absolutely necessary, and for this latter reason the net gain in a lesser fuel consumption should be a large one to justify the use of gas engines for large powers on these plants.

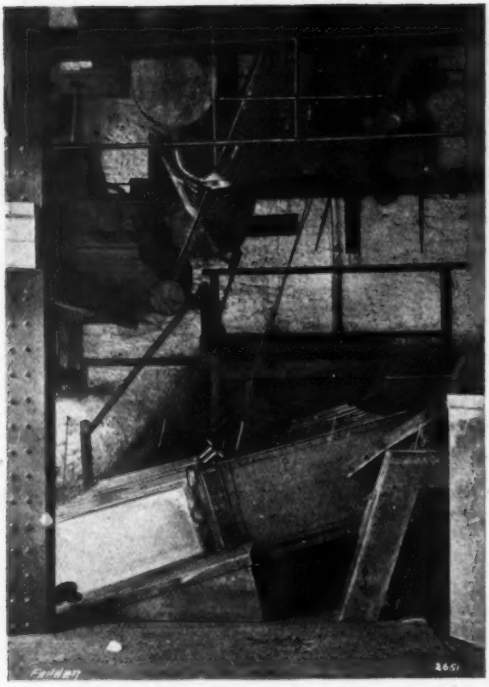
I do not think a compressor has been yet designed for driving direct off the crank-pin of a gas engine, the compressor cylinder being placed directly opposite the engine cylinder, with the connecting-rod on the same crank-pin. Space would be saved in this way by dispensing with belts, as well as a saving of power, and the arrangement would minimise what is often a fruitful source of trouble, namely, the stress on the main bearing of the engine, which would be greatly reduced by direct compression.

I have known a large gas engine indicating 100 h.p. to work successfully in this way, driving an air compressor for use with pneumatic tools.

Compressors would have to be specially designed for high piston speeds to suit the case, high piston speeds being necessary to efficient working of gas engines.

By far the most usual and best plan for

CAN TANK TIPPING FRAME AND REFILLING GEAR.



VIEW SHOWING ICE DUMPED WITH TIPPING FRAME DOWN.

driving large compressors is to drive them direct by steam. There is then no loss of power or trouble with belts, and there is less friction by having only one main crank-shaft, and a saving of labour in the minimum number of working parts to attend to and keep in repair.

These direct-driven compressors take various forms.

The simplest is a single-crank engine with one cylinder, driving a compressor cylinder fixed in the same bed off the tail rod of steam cylinder, tandem fashion, and this form is varied by having two steam cylinders, high and low pressure, either condensing or non-condensing. Large compressors of the ammonia type take up considerable space under this form, so that they are generally made with horizontal steam engine and vertical compressors directly over the one main crank-shaft. Sometimes the compound engine will have cylinders side by side on two different cranks, and the compressor arranged vertically off a crank central between the steam cranks; or the engine may be tandem, working in a central crank, and two compressors, vertical, arranged one on either side of the steam crank as in the "Boyle" machine illustrated, page 141; or the compound engine may be side by side working two compressors, one off each of the same engine cranks.

Some compressors, too, have been designed on the trunk system, having the crank-shaft and fly-wheel in the centre, and the steam cylinder on one side and the compressor opposite on the other. The evaporators and condensers will be at any convenient part of the engine room, and connected to the compressors by two single pipes, one to Suc. and one to Del. side of the compressor.

The carbonic acid gas machines are made generally horizontal throughout. The space taken up by the compressor is considerably less for the same power machine than in the case of ammonia, one of the factors which make the carbonic acid machine more suitable for use on board ship.

A very powerful and compact form is that known as the Triple-Expansion Duplex type, with the steam and refrigerating condensers both contained in the bed of the engine. The air, feed and water circulating pumps are also fixed to the main bed and driven off the main crank-shaft. The evaporators and brine pumps are placed separately in the rear of the machine or in any other more convenient place.

This Duplex type, illustrated on p. 144, is so arranged that it can be worked each half separately whilst the other half is entirely at rest. One half working day and night will perform all the refrigeration required. If the whole is used, part time

only need be worked, or the revolutions reduced. This arrangement obviates any difficulty in maintaining temperatures should a breakdown occur on one half. The high-pressure and intermediate steam cylinders are tandem on one side, and the low-pressure cylinder on the other, and the two compressors overhanging the bed are driven off tail rods from the engine cylinders. The compressors can be easily disconnected from the tail rods, so that the whole triple-expansion engine can be run on the one compressor if the other is disconnected temporarily. There are two fly-wheels which form a coupling in the centre of the crank-shaft. These can be disconnected, and the high-pressure and intermediate cylinders can be run compound condensing or non-condensing, and drive their own compressor, or the low-pressure can be run with live steam condensing or non-condensing, and drive its compressor. In the usual way, when no overhauling or repairs are going on, the whole triple-expansion engine will be used on both compressors, and run at a speed to suit the refrigeration required. I have described this Duplex type at some length, since I think it may be fairly said to constitute the *par excellence* of refrigerating achievement. It is an excellent form of machine for either land or sea use, and one such machine is all that is required. In cold-storage work it is always advisable, and should be considered necessary, to have either a Duplex machine or two separate machines, as any temporary breakdown, if only for a day or two, might prove disastrous to thousands of pounds worth of goods, if one machine only was provided.

In the case of ice-making only, where a sufficient stock can be held in store the consequences need not be so serious, since, if the stock of ice is kept in store at a fairly low temperature, say at 25 degs. Fahr., it will take some time to rise to 32 degs. Fahr., when it begins to melt. However, considering the necessity of working continuously night and day, and thus subjecting all machinery to the severest test, it is decidedly preferable to have all parts as far as possible in duplicate.

In ice works and cold stores there will always be machinery not directly connected with the refrigerating process, such as a dynamo for lights, power travellers for lifting the ice, power lifts, hoists, &c. In large works, an auxiliary engine does this duty, in case the refrigerating machinery is not needed to be run, or is temporarily stopped for adjustment or repairs. But the main engines, too, are fitted with a driving pulley to the main line of shafting, so that they can usually do this work, thus avoiding the uneconomical plan of running a small engine at all times.

In laying down such works as these, it is necessary to carefully consider all the conveniences connected with the receiving and delivery of goods, and the handling of ice on its way from the tanks where it is produced to the customer at the door. Such matters, though apparently trivial, contribute largely to the general economy of working. A certain daily output of ice and the maintaining of stated temperatures over a certain test period are not the only important considerations in laying down the plant.

We pass on now to consider the chief features of the tank room. Here the ice is actually made and delivered on to a platform ready for either direct delivery to customers or for stowing away in a cold store, where a stock may be kept to make up the supply on days when the demand is greater than the possible daily output.

The bulk of this room is taken up by the ice tanks, and at one end is the platform on which the ice is "dumped" after lifting, and on which is placed the crushers for grinding the ice small for use in the fish trade. There will also be here the travellers, hoists and lifts necessary for moving the ice in bulk.

There are two forms of tanks in general use in this country, making what are called respectively can ice and cell ice.

The can ice is made in from 1 cwt. to 2 cwt. blocks, and is opaque in appearance, the reason being that the small quantity of air always contained in water is not separated from the ice block, but becomes frozen in in the form of small bubbles and needles, thus causing the ice to have a white appearance not trans-

parent. There are several mechanical methods of agitating the water during the process of freezing, and by which the air is got rid of more or less successfully, and clear ice produced on the can system.

But when large blocks of crystal ice for table and show purposes are required, the cell system is used, by which method blocks of from 2 cwt. to 6 cwt. are made perfectly clear ice, and the ice thus produced is purer than the water from which it is made, by reason of the impurities being removed as they naturally freeze out. This process, giving the best results, is more expensive in first outlay on plant, and also more expensive to produce per ton.

A third method, known as the plate system, is largely used in the United States of America. Large slabs of ice by this process are made, weighing several tons, and are sawn into suitable blocks by a number of circular saws equidistant on a single spindle. The ice slab is carried on a movable table past the revolving saws and sawn into strips, the table then is revolved one-quarter round, passes the saws again, and thus the strips are sawn into blocks. This ice is from 2 ft. to 4 ft. thick, and quite clear.

CAN ICE.

The construction of the can ice tanks is very simple. We have a plain rectangular iron tank, about 4 ft. 6 ins. deep, for, say, 2-cwt. blocks. The tank is well insulated on the sides and bottom to prevent, as much as practicable, heat entering the tank from the outside. The top is covered with portable planks. The tank is partially filled with brine—made by mixing water with chloride of calcium; this does not rust the ironwork, whilst common salt would. The tank will be from two to three times as long as it is wide—say, for making 20 tons of ice per day, 16 ft. by 40 ft.

Placed across the tank inside, and covering the whole area, will be a series of light frames made of steel joists. These

CANS REFILLING.

frames are portable, and each carries a number of ice moulds or "cans" made of thin galvanised iron or copper. These moulds contain the water to be made ice. For a 2-cwt. block the mould will be 8 ins. by 21 ins. by 4 ft. deep. The frames are supported at the ends by angle irons bolted to the sides of the tank and running the entire length. For 20 tons of ice per day there will be required 300 moulds, say 20 frames carrying 15 moulds each. Each frame lifted would carry $1\frac{1}{2}$ tons of ice, and, say, when all the machinery was in its best working efficiency, 15 of these lifts could be made daily; we should then have as our daily output $22\frac{1}{2}$ tons, or $2\frac{1}{2}$ tons to spare for any inefficiency. When all the frames are in the tank, and the moulds filled with water, the brine level inside the tank will be at the same level as the water inside the moulds.

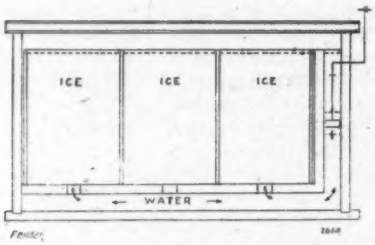
We will assume we have not been working. The brine and the water are at the same temperature. We start the circulation of brine and the refrigerating machine. The brine leaves the evaporator and passes in at one end of the ice tank, circulates past all the cans, and leaves the tank at the opposite end, on its way back to the evaporator. As the brine passes over the evaporator coils it becomes cooled by conduction of heat to the lower temperature of the gas inside the coils, and when returned again to the ice tank it absorbs heat from the water by conduction through the sides of the ice moulds; and this process continues until all the brine and water has been lowered to a temperature of 32 degs. Fahr. Water cannot be reduced below this temperature as water. Immediately more heat is abstracted part of the water becomes ice, the rest remaining at 32 degs. Fahr. But the brine does not freeze, except at much lower temperatures, according to its density; and this is the reason why brine is employed as a medium for carrying heat at these lower temperatures. As the brine becomes reduced below 32 degs. Fahr. a thin film of ice forms on the inside of the moulds, and this gradually grows until the whole becomes a solid block of ice closing up at the centre.

On first starting the plant all the moulds become ice at once, but in ordinary continuous working the frames are lifted one at a time at equal time intervals night and day, so that the tank will contain moulds of ice of varying thickness, from solid blocks down to moulds containing no ice, but only water under the process of cooling down to freezing-point. Thus the brine is supplied steadily with heat at the same rate as the refrigerator abstracts it, and remains at one temperature on its delivery from the evaporator, namely 18 degs. Fahr., and will return at 23 degs. Fahr., after it has abstracted a proper quantity of heat from the ice tank.

I pass on now to the interesting process of lifting the ice, thawing off, dumping, refilling the cans with water, and placing them again in the freezing tank. These operations are performed consecutively, and altogether take about ten minutes, and employ the labour of one man only.

Above the tank, and running its entire length, is a power traveller, driven by rope or electric motors. The traveller first lifts and removes the planks covering the frame and set of cans at the end of the tank at which the brine enters. It then lifts by two or more steel ropes the entire frame with the $1\frac{1}{2}$ tons of ice, or it may be 3 tons in large tanks.

Having raised the cans clear of the tank covers the traveller is moved a few feet forward to directly over the thawing off tank. This is a narrow tank containing warm water and just large enough to immerse the frame and cans. The frame and the top of the cans will be covered with frost, and the ice blocks will all be hard frozen to the inside of the cans. The frame and cans are now lowered into this thawing-off tank and allowed to remain in the warm water about two minutes, while the ice is thawed off the sides of the cans. The cans are again lifted and carried a few feet farther forward and lowered into the tipping frame. This frame, consisting of a bottom and front piece only, is hinged the entire length. The cans are lowered on to the bottom, and the front piece of the tipping frame prevents them from sliding forward. As the traveller continues to lower out,



SECTION OF CELL TANK FOR MAKING CLEAR ICE.

the cans tip forward at the top and are held in position at the bottom, turning with the tipping frame on its hinges. They leave the vertical position and gradually take the horizontal, and then lower still until they reach a point at which the ice blocks slide out of the cans by gravity on to a prepared slanting platform, which guides them on to the horizontal platform, where they are ready for despatch to customers. The cans are now again lifted to the vertical position, and just above the tipping frame, or, better, at the other end of the ice tank, is the refilling tank. This is a tank similar in shape to the thawing-off tank, but is divided up into sections, each section containing the exact quantity of water to refill one can. Each can comes to a position opposite to a section in this tank. At the bottom of each section is attached a pipe, with a flexible rubber hose joint. All these pipes are fixed on a single frame of light wrought iron, hinged in line with the rubber joints. These pipes are of such length that when in a vertical position the tops of these are above the water level in the refilling tank, so that the tank can be full of water, and the pipes being turned upwards no water will flow out. As soon as the ice cans are brought up to the refilling tank, the whole frame carrying the pipes is lowered over, and each section of the tank is emptied into its can opposite at one time; and whilst the refilling is going on a worm and wheel is put in motion, and by means of thrusting arms all the remaining sets of cans, with their frames, are moved the space of one frame forwards along the tank, so that the space in front from which the last set of cans has been taken out is refilled by the next set to be lifted, and room made at the back end of tank to receive the last set just lifted, so that we always have ice at the front end of the tank when the cold brine is coming in ready to be lifted, and at far or back end fresh water being cooled down. In this way the lifting and freezing process goes on quite regularly, and the brine can be kept at even temperatures always for the same part of the tank. Delivery to the tank one end 18 degs. Fahr. and return to the evaporator at the other end 23 degs. Fahr.

The cell tanks are not so simple in construction or working. They are more costly to put down and also require more refrigerating power than the can tanks for the same output of ice, but the advantage is gained in the production of large clear and perfectly pure blocks of ice. This ice has a better appearance and is perfectly fit for table use. A great advantage, too, is that it travels well by rail. The blocks, instead of being flat, become nearer to cube dimensions, thus exposing less surface to the outside for melting. The exposed surface is also less by reason of there being no cavities formed by air-bubbles. The process of agitating the water gently as it freezes, causes all impurities to freeze out and settle to the bottom, where they are removed.

The cell tanks, measuring each about 10 ft. square and 5 ft. deep, are made of pine planks 3 ins. thick, laid horizontally on their edges one above the other, and bolted together with long bolts, each bolt running through the centre of all the planks forming one side or bottom. The planks are tongued and grooved together, and jointed with cooper's putty. The ends are "housed" into the sides, and the bottom is also "housed" on, the whole being watertight. A number of these tanks are placed in rows according to the size of the plant. The size of tank we have mentioned will produce 21 blocks of ice of 6 cwt. each, and the time taken to freeze this size of block is about 80 hours, so that in every 80 to 85 hours we shall be able to lift from each tank 6 tons 6 cwt. of ice. The tanks are lifted not all at one time, but singly, so as to maintain the brine at an even temperature, and to

give to the machines an even and constant duty in abstracting heat.

The cells are formed by a false bottom in the tank, and hollow iron sections resting on this bottom through which the brine is circulated. Through the false bottom there are a number of holes about 3 in. by 1 in., one for each cell. It is through these holes that the gentle motion known as "agitating" is given to the water in each cell whilst the freezing process is going on. Along one side of the tank is a false side, and between this false side and the real or outer side is hung on suitable levers a plank forming a paddle when the tank is full of water.

Each tank is fitted with a valve for filling with fresh clean water at the top, and with another at the bottom for drawing off the water that does not freeze in the spaces formed by the false bottom and false side, and with it the impurities which have frozen out. A hose is used for thoroughly washing down the inside of tanks after each freezing process, before the tank is again refilled. The wooden paddle running the length of one side of the tank does not fit the space in which it moves tightly, but is just a loose fit. To fill the tank, the water is run into this paddle-way, which communicates along its whole length with the space formed under the false bottom. As the water has gradually filled up this bottom space it rises through the holes made in the false bottom to each cell, and is allowed to fill the cells to within 6 ins. of the top. The water, on becoming ice, will expand and fill up the remaining 6 ins.

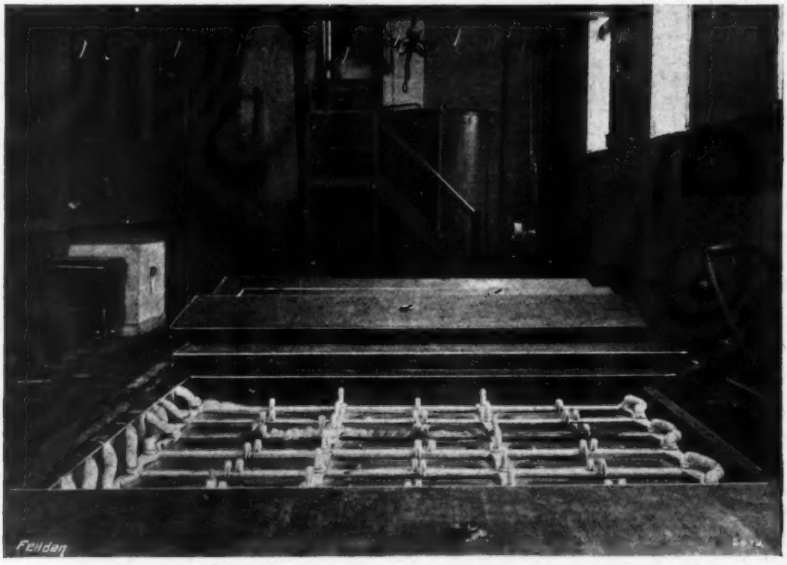
There is a long rocking lever running the entire length of the row of tanks, and when it is required to start the agitating paddle in any particular tank, the supporting levers of the paddle are connected to this by a loose lever, and the paddle is caused to move gently up and down about a 6-in. stroke. By adjusting this loose lever in a slot, the stroke of the paddle can be lessened as the freezing proceeds, until near the end it has to be disconnected to allow the central core of the block to freeze up. It will be seen, in the diagram on page 332, that as the paddle descends, the water level will fall with it in the space at the side of the tank, and rise through the holes in the false bottom in the main part of the tank; and as it ascends the water will descend in the tank, and follow the paddle in the original level. In this way a small stream of water is kept running in and out of each cell through the hole to the centre. As the air, always contained in water, freezes out in bubbles, it is by this motion of the water just prevented from hanging to the surface of the ice, and rises to the top, where it can get away. If it were not for this brushing away of the air bubbles, they would become frozen in, and, forming numerous little air-cells, would render the ice opaque in appearance. Likewise, the impurities, as they freeze out, are brushed off, and, being heavier than the water, they sink and settle through the central holes into the space below formed by the false bottom. And these are thoroughly washed away after each process of freezing.

Although the best and purest of water obtainable is always used for ice-making, yet ice made in this way with anything but clean water would, I believe, be quite as pure. The "freezing out" process is a natural one, as can be seen by the clear ice formed on the water of a stagnant and dirty pond in winter, the necessity being to remove the impurities after they have frozen out of solution to prevent them being trapped by the next layer of ice. In the pond they fall away by gravity. Since in manufacture we freeze from the sides inwards, they can cling to the vertical surface, and have to be removed by the agitating process. In the can ice, where no agitation is used, they are found mostly at the bottom of the block, but largely in the centre core, which is the last part to freeze up. In this central core they will be thickest at the bottom, but are plainly seen to vary near the top, as I have proved by experiment with muddy water.

In the case of a river or lake, freezing from the top downwards, the impurities are sure to freeze out and settle down to a large extent, but it is not necessary that they all should; and, indeed, ice of

this description has been found by analysts to be anything but pure. I have produced ice by the agitating process from water not pure, but on analysis the water obtained from it was pronounced "absolutely pure."

It will be interesting to notice here, since we have explained briefly the process of manufacturing ice, that this ice, after all, is entirely a production of Nature, made, and made only, by Nature's laws. No chemicals are used in connection with the water; the water is merely brought in contact with cold metal surfaces, and follows its own law of freezing at the temperature of 32 degs. Fahr.



CELL TANK, WITH COVERS REMOVED, READY FOR LIFTING ICE.

We are dependent upon Nature not only for the fact that water freezes after a certain amount of heat has been abstracted, but for every step we employ in abstracting the heat; and looking at it from one point of view, it is very little indeed that Nature does not do in the process. To quote an expression of J. S. Mill, in describing manufacturing processes, he says: "The properties of Nature do all the work, when once objects are put in the right position." And so in this case we can take it, from the coal in the boiler furnace to the ice on the platform, we are dependent upon Nature for performing the whole of the work, if only we put objects in the right position; and, fortunately, if we do not obtain results, we have not got to think whether Nature or ourselves are wrong. We are always sure Nature is right, and have to find out where we have something "out of position." A very little consideration will suffice to show how dependent we are on Nature, not to mention the laws of converting heat into work before we begin to refrigerate. We have the law by which the gas is heated by compression and raised to a higher temperature level. Then that of cooling by conduction, and the change of state by compression and cooling into the liquid form. Then absorption of heat by evaporation, and the brine by conduction is enabled to collect, convey, and deliver heat,

and so on. Thus the whole working is Nature's, and the finished article is strictly a production of Nature, and to call it artificial is only a convenience to distinguish it from the same thing made by another natural process. The only difference I know between the so-called artificial ice and natural ice is the difference in "direction" in which the freezing takes place. With manufactured ice the freezing takes place from the four sides inwards, and with the natural ice from the top downwards; and this must account for any difference in behaviour between the two products when exposed separately to the atmosphere: both are frozen water. It can be proved by experiment that 1 lb. of either has precisely the same cooling power—that is, it will require the same number of thermal units of heat to melt 1 lb. of either.

As in the can system, the blocks have to be thawed off the sides of the cells before they can be lifted. They have been frozen by cold brine entering one section and travelling through it, and returning to the evaporator by the next section, and so the sections work in pairs, and all the ice in one tank becomes frozen up at once. The covers are now taken off the tank, and the cold brine delivery is closed and a warm brine delivery is opened. This warm brine is delivered from a separate pump and a special warm brine tank, where the brine is made warm by a steam coil or other means. As soon as the warm brine has displaced all the cold in the cell sections and returned it to the evaporator, the return to the evaporator is closed, and a separate return to the warm brine tank is opened. In this way the cold brine is not warmed to serve as warm brine, but a separate supply is used and kept warm for the purpose; and similarly when the cold brine is again required for freezing fresh water, it first displaces the warm brine left in the sections into the warm brine tank; the valves are then changed over, and the cold brine returns to the evaporator.

This prevents as much as possible any waste in refrigerating power. The thawing-off process will take 1½ to 3 hrs. The blocks are then drawn from the tanks.

Hooks of iron are frozen during the process of freezing into the sides of the blocks, two to each block. A yoke piece is fastened to these hooks, and a traveller with transverse motion lifts each block separately, and carries it to the platform; or on large plants, a traveller carrying a beam, but with no tranverse motion, is used, and a number of blocks lifted at one time, each lifted clear of the bottom of tank first by separate hand tackles fixed to the beam, and, when all the blocks are loosened, the traveller lifts the whole clear of the top of the tank and carries them to the top platform in front, to be disposed of as required

It is necessary on large plants to have a store of sufficient capacity to hold at least two or three days' output. This stock on hand is used to supplement the supply on days when the demand may be greater than the daily output. The machines then can be kept working at their full capacity, which is the best economy. On smaller plants, when there may be only one ice-making machine, it is necessary to have a store of much larger dimension relatively to the output, so that, in case of breakdown of the machine or other temporary stoppage of the plant, there will be a sufficient stock to supply any possible demand for some days, as not only will the output be stopped while such repairs are being effected, but it will be necessary to work the machine perhaps two or three days before the brine, which will have risen in temperature, is brought down sufficiently to allow of the total output again being produced; and a larger store still is required where it is necessary to stock a sufficient quantity of ice to supply the demand in the three hottest months over and above the supply of the daily output. It is generally considered that it does not pay to store large quantities of ice in this way; say, with a 20-ton plant, to store 15,000 tons, so as to be able to supply nearly double the output for the three hottest months. But if the plant is well arranged so that the storing and taking from store of the ice can be done with a minimum of labour, and also if the arrangements for cooling the store so as to keep the ice from melting is well

arranged with a minimum amount of refrigeration, there is no reason why it should not pay. A plant laid down on these lines would require less capital outlay than is required where a 40-ton plant without storage capacity is used; and since the greater amount of labour on an ice plant cannot be dispensed with in winter, it is just as well to keep it fully employed for as much of the year as possible, and this can be done by filling up the store in winter.

An ice store must on no account have an entrance at the bottom, but always at the top. The air is cooled to about 25 deg. Fahr. by brine grids — that is, grids of 1½-in. pipes at about 4-n. centres placed on the ceiling of the store. Immediately the top air in the store is cooled it becomes denser and heavier than the warmer air below, and then falls away from the brine grids, and the warmer air rises, which in its turn is cooled, and so a constant circulation of the air is maintained, and the store kept at very nearly the same temperature top and bottom. You cannot cool a store from the bottom upwards to any appreciable height. The air will become dense and cold at the bottom, and remain there, whilst a few feet up the ice will be melting; yet I have actually seen this tried on a store sufficient to hold 1,000 tons or more, and with a plant capable of turning out 50 tons of ice per day. The air was cooled by the uninsulated bottom of the ice tanks, and allowed to enter the ice store at the bottom. It is needless to say that, besides the waste by heat entering the ice tanks having no insulation, the store was quite useless Such mistakes are unnecessary, and account for small dividends. For the same reason that cold air is heavier than hot air we cannot afford to open the store even for a few minutes at the bottom. The cold air at once rushes out, and the warm air from outside takes its place, and all the energy expended on the machine in cooling this fresh air is wasted, which could have been usefully employed in making additional ice.

An ice store should be on the ground floor, and the ice tanks and landing platforms immediately over it, and on the first floor. The reasons, I think, will be seen to be obvious. Both ice tanks and ice store must be well insulated, to prevent as much as possible entrance of heat from the outside. But however efficient the insulation some heat will always be penetrating every foot of surface; otherwise, once having cooled the store to the desired temperature, it would remain cool. It is the continual pumping out of this heat, constantly penetrating the walls and insulation, that the refrigerating machine has to accomplish. Now if we have our ice tanks on the ground floor, we have heat constantly penetrating the entire surface of the bottoms and heating the brine. But if we have them on the first floor, and directly above the ice store, any leakage of heat from the ice store into the ice tanks would be useful in cooling the ice store, or, *vice versâ*, any leakage of heat from

THAWING-OFF TANK WITH ITS WARM BRINE PUMPS.

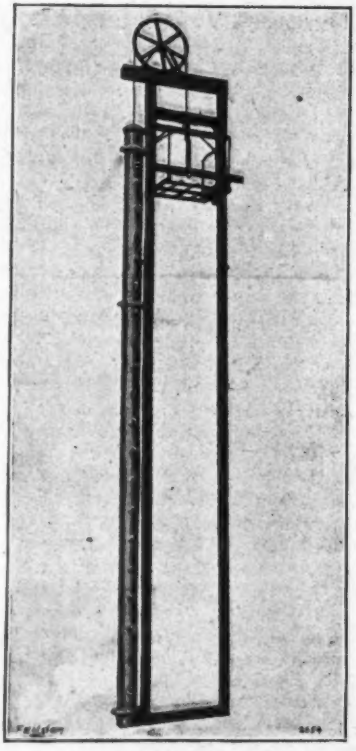
the ice tanks into the store would be useful in cooling the ice tanks. But if the brine in the ice tanks and in the ice store grids is kept at nearly the same temperature, which would be the case, there will be no leakage of heat either way, and neither the top of the store nor bottom of tanks need be insulated at all, except that it may be necessary to keep the store cool sometimes in winter to preserve a stock of ice whilst the tanks are not being worked. And this will be just the time when leakages of heat (if we may so call it) are least on all parts of the plant, owing to the cooler outside temperature. For such times all the insulation necessary between the bottom of ice tanks and top of cold store will be to fill in between the floor and ceiling with slag wool or charcoal shavings. There will still be the same leakage of heat into the ice store through the walls, and these must be insulated. But if these are surrounded with cold stores for storing provisions, &c., and these again by the passages leading to these store rooms, we have, I think, an ideal plant from the view of waste of "cold," or strictly wasteful entrance of "heat." But, after all, this is not the chief point for which I am advocating this arrangement, but only one in which a considerable economy can be effected, over the plan of having tanks and store on the ground floor together.

With this latter arrangement all the ice to be stored is delivered on the ground floor, and has to be lifted to the top level of the ice store and then lowered down inside the ice store to the level at which the store is at that time being worked. This necessitates three men with a friction hoist or two lifts, one inside and one outside the store; and at the top the ice must be transferred from one lift to the other. This also necessitates three men to work it. Nor is a closed lobby practicable at the bottom of the store. With this plan a lift-way has to be left through the tiers of ice already stored to enable the hoist to be worked inside. This is a source of great danger to the man below, through ice blocks slipping from the grips; and also to the man above standing on the ice, in case he should slip and fall down the lift-way. The process of lifting and handling one or two blocks at a time in this way also is much too slow.

But if the ice tanks and platform are above and the store directly beneath, all is plain sailing, not only for storing the ice but for crushing it and delivering in block to customers.

Directly in front of the tanks will be descending lifts into the store below. The slanting-way for receiving the ice from the tanks two or three tons at a time will be the bottom of a lift itself, and fully loaded direct by the travellers at once for descending into the store. The slant could be hinged, so that when it reached the ice level in the store it could be reversed and the whole load shot off and part of the way across the store to where it is to be stowed. And when ice is taken from the store the lifts can be loaded below and brought up to the platform level and the ice shot off to near the crushers. For the cell ice the lift bottoms will be level, and these larger blocks must be dragged off in the store. I do not think this plan of storing ice has yet been tried; and I feel sure there is plenty of room yet for improvement in these and other respects of general arrangements with ice works, which can only to be expected when we hear on all sides that the industry is only in its infancy at present.

A further advantage in having the ice made on the first floor, and especially where the bulk is for the fishing industry, is the readiness with which the ice can be crushed and sent by gravity through a shoot into the fishing vessel's bunker, with no labour except feeding the blocks into the crusher. This obviates the necessity of crushing the ice in a pit and using an elevator to raise it to the necessary level after crushing for falling into the vessel, or the more costly plan of filling bags or barrels and carting the ice and carrying it on board. A fact worthy of note in this connection also is, that ice crushed and allowed to fall from a considerable height into the hold of a vessel becomes tightly wedged together, and not only takes up less room, but does not melt so quickly as ice carried on board and lightly thrown together, the reason being that the spaces between the particles are more closely



LOWERING MACHINE.

filled up, and the total surface exposed to the air is less and circulation of air through the mass is retarded.

It is true with the ice tanks on the first floor we do not have the block ice so handy for the town customers and for rail; but this is a minor drawback. Having made our ice above, gravity, without any power appliances, will do the lowering on to another platform below, or a sliding way can be used which the Americans in the ice trade call a "run way," being merely a circuitous slanting way to guide the block. Or if the room does not admit of this being long enough to prevent too steep a gradient, a very simple lowering machine as illustrated above can be used, and is used in America, not only for lowering ice blocks, but any packages into ships' holds. This air-pressure lowering machine consists of a cage to receive the ice block, and the cage is guided by the two supporting angle irons, and is more than balanced by a weighted piston, fitting the steel air-tube at the back. The air tube is perforated to allow the air to escape when the piston rises during the lowering of the cage. The top perforations are regulated in size and made smaller, to cushion the air as the cage reaches the lower level. As soon as the cage is loaded it falls very rapidly, and is brought gradually to a standstill in the last two or three feet of the fall. On reaching the bottom level the cage engages with a lever and is automatically upset, and deposits the load on the lower platform. Immediately the cage is unloaded it rapidly ascends by the weight of the loaded piston in the air tube. The piston and cage are brought to rest by air cushioning at the bottom of the tube in a similar way as before. This lift will deliver the blocks below as fast as a man can feed them on to the short "run way" at the top. And if we can sell ice to the town customers at this rate, and with so little labour in handling, we have not much to fear in cost or inconvenience.

The same refrigerating machines precisely are used for cold-storing work as for ice-making, and when an ice factory and cold stores are in one set of buildings, the brine piping and connections are so arranged that any machine can be used for either purpose. In ice-making we have to collect the heat from the water to make it ice, and for cold-storing purposes we have to collect the heat in the stores and deliver it outside. To maintain the low temperatures in the several store-rooms it is necessary, not only to abstract the heat from the goods in store, but to be constantly abstracting the heat penetrating the walls of the building. When once the goods have been reduced to the required temperature, no further heat has to be abstracted from them, and the machines then have only to keep down this leakage of heat from the outside. To minimise this leakage as far as possible, it is necessary to insulate all the walls, floors, and ceilings of the buildings forming the stores. It is also necessary to keep out damp as much

as possible, since all damp or water vapour is condensed in the lower temperature inside and becomes frozen in the form of frost on the outside of the brine grids, and this means extra refrigerating work for the machines, really making so much useless ice with the trouble of having to clear it away from time to time. There are numerous plans for insulation, the simplest perhaps being a single thickness of from 7 to 9 ins. of insulating material such as flake-charcoal, slag-wool or, for temporary constructions, sawdust, placed on the inside of the wall and held in position by match-boarding. Air spaces of from 1 to 3 ins. are sometimes used between the wall and the insulating material. This materially increases the insulating efficiency, but requires double the quantity of boarding and extra studding; and to prevent damp the walls are coated with pitch, and all boarding fixed in double layers with waterproof paper between. How effective the insulation should be is a consideration in first cost. The better it is, the less work there will be for the refrigerators to do. But, however good it is made, we can never prevent some heat penetrating to the inside; and, since the temperature inside must always be the same, the amount of heat penetrating will always be proportional to the temperature outside. The higher the temperature outside, the more heat will penetrate and the more work will be required of the machines. Thus it will be in summer that the machines will be required to work continuously night and day, whilst in winter from 2 to 6 or 8 hrs. may be sufficient; and it is not uncommon to find that in winter the stores which are usually kept at 35 degs. to 40 degs. Fahr. become naturally below these temperatures by reason of the outside temperature being below. Then, of course, no refrigerating work at all is required; and it is needless to say these stores are then probably empty of goods.

There are two chief methods of refrigerating stores. The "cold dry air" method, where the cooling pipes are closely packed together in a stack of grids and placed in a closed box, the air from the several stores being drawn by a fan and forced over these cold pipes, and again delivered at a lower temperature to the stores. The air thus kept in continual circulation is conducted by wooden trunks, one main delivery trunk from the cooler, and one return to the cooler; and each store-room has its branch delivery and return trunks connected to the mains, and fitted with slides, so that the quantity of air in each store can be regulated to maintain the desired temperature. Inside each store-room the delivery trunk will run along one side, with the return trunk on the opposite side of the store. The trunks are not connected to each other, but each has several openings along its length. The cold air enters the store by the delivery trunk, and crossing the store, passes over and through the goods, picking up heat; and, leaving the store by the return trunk, delivers the heat to the "cooler," whence it is again cooled for further and similar duty. The same air is always used, except so far as fresh air is required for ventilation. This, as a rule, for these low temperatures, is more than sufficiently supplied by the unavoidable opening and shutting of doors during the daily receiving and delivery of goods. This method has the advantage of preserving the air in a very dry state. As the air passes over the low temperature of the cooler (about 10 degs. Fahr.), the moisture at once condenses on the cold pipes and becomes frozen in the form of frost, rendering the air delivered from the cooler very dry. This dry air, entering the store-room, readily picks up any moisture off the surface of the goods and again deposits it on the pipes. Thus it performs in a regular and constant manner the twofold duty of the collection and delivery of heat and damp, with the result that we can maintain a "cold dry air store," where certain goods are kept in a much better condition than would be the case in a damper atmosphere.

The other method is by having the cold pipes fixed on the ceilings and walls of the stores themselves, as was the case in cooling the ice store. By this method, however, the air is not made so dry. The moisture settles on the pipes nevertheless, but not to the same extent. The pipes

become more slowly coated with frost, and when the frost attains a thickness of from 1 to 3 ins., it has to be chipped off, causing considerable inconvenience and labour, whilst on the other hand the frost on the "cooler" can be melted off by closing the main trunks to the stores and opening others to the outside atmosphere. The fan will then blow the warm outside air over the pipes, and thus melt the frost, the water being caught in a lead tray and drained to the outside.

We have mentioned these cold pipes of the "cooler" and in the stores, but these can be cooled in two ways—either by direct expansion or by brine circulation. In direct expansion the pipes form at once the evaporator of the machine, and contain the expanding gas, the gas receiving the heat from the stores directly by conduction through the pipes. No brine is used in this case, and there is no separate evaporator in the engine-room. With the brine circulation an evaporator with its casing is used, as before described, and the brine then serves as a medium for conveying the heat from the stores to the evaporator coils.

The method of handling goods in cold stores may be said in the main to be the same as for handling similar goods in ordinary warehouses. But special labour-saving devices should be taken full advantage of, so as to reduce the staff as far as possible, to avoid discharging more hands than necessary in winter or slack times. No windows are used for light in cold stores, as they would conduct too much heat in from the outside. Electric light is used and supplied on the premises. All stores are provided with a closed lobby, so that the outer door may be closed air-tight before the inner door into the store itself is opened. This is necessary, to prevent loss of cold air. One lobby or passage may serve for several store-rooms.

The whole building should be as compact as possible, and as nearly as possible resembling a cube in shape, so as to present the minimum of outside walls for the entrance of heat with the maximum of inside capacity. As I have before indicated, for a combined ice factory and cold stores an ideal arrangement would be to have ice tanks in the centre with ice store directly below; these surrounded on two sides by cold stores of one, two, or three floors, as required, and with their lobbies and passages on the outside; the office entrances at one end and the engine-room, boilers, and workshop at the other. But, unfortunately, we are sometimes bound to a site or sites which do not lend themselves to an ideal arrangement. In such cases as these careful thought is required to make the best of the opportunity afforded. In this business, as in all others, ultimate success depends on starting rightly, and, although there is still room for improvement, there can certainly be no doubt that another important factor of our industrial progress has been well established and has come to stay.

A. C. L. Back

Electrical Machinery at the Glasgow International Exhibition.

By SYDNEY F. WALKER, A.M.INST.C.E., M.I.MECH.E., M.I.E.E.

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II.—THE ELECTRICAL GENERATING STATION.

THE same completeness that is shown in other matters is shown in that of the plant employed for generating electric currents for the lighting and power service of the Exhibition, so far as the condition of the city arrangements would allow. Glasgow was one of the few towns in which the engineers, like the wise virgins, looked out for the future, and adopted the continuous-current system for their lighting service, instead of following the then prevailing fashion and using high-tension alternate currents. As a consequence, Glasgow has paid its way, almost from the first, with its electrical plant, and it has one of the most extensive plants in the kingdom. But the fact that the town service is on the three-wire continuous-current system, coupled with the wise arrangement made of connecting the town supply service to the Exhibition sub-switchboards, as already described, has necessarily limited the generating plant to those machines that would fit in with the current furnished by the town supply service—viz. 500 volts. And the generators are therefore all arranged to furnish either 250 volts, half the pressure of the supply service, or the full pressure, 500 volts.

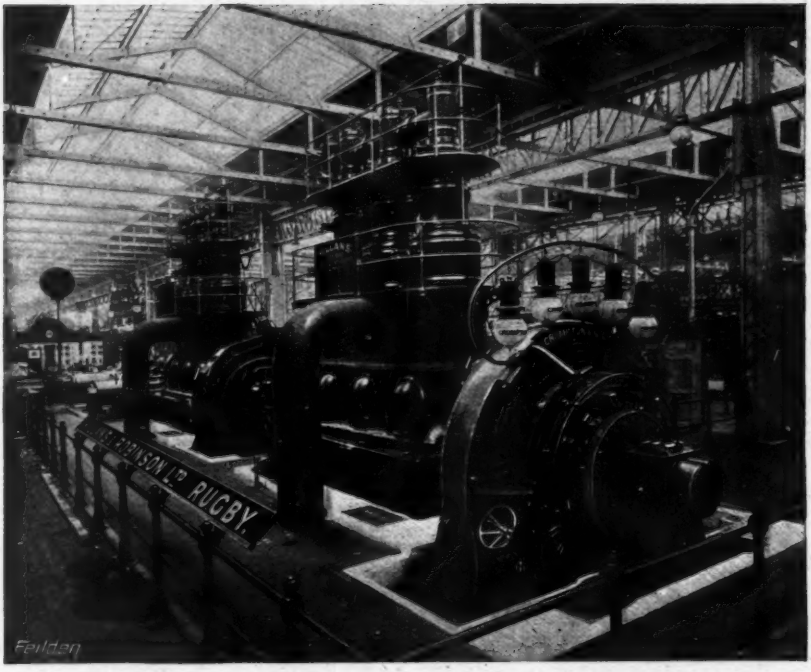
With this qualification the range of apparatus employed in the generating station is very wide. Commencing with the boiler house, there are four Lancashire boilers, with rocking furnace bars, made by Messrs. Penman & Co., of Glasgow; two of their water-tube boilers for land work, by Messrs. Babcock & Wilcox, fitted with their chain type mechanical stokers; two water-tube boilers made by The Stirling Boiler Co.; one Economic boiler made by Messrs. Davey, Paxman & Co., and one marine water-tube boiler by Messrs. Babcock & Wilcox. The Stirling boilers are fired, one by Vicars' mechanical stokers and the other by means of producer gas from a gas producer exhibited in operation by Messrs. F. W. Mason & Co., of Manchester. The well-known economiser of Messrs. E. Green & Co., the Berryman feed-water heater, the Excelsior heater, filters, and oil separators are also shown in operation, as well as pumps by the Worthington Co., and Messrs. Weir & Co. The latter firm have produced a very striking effect by allowing the water raised by some of their pumps to fall over a long artificial weir, constructed at the end of the Machinery Hall, near the power station, in one large sheet.

It will be seen that in this portion of the Exhibition the actual condition of things is accurately represented. Thus in the struggle—on the one hand between the old type of boiler and the newer water-tube boiler, and again between hand firing and mechanical stoking, and also between coal and producer gas, as fuel—the competitors are all represented.

In the generating plant also, with the qualifications mentioned above, the same thing holds good. The struggle that is taking place between high- and low-speed dynamos, the passing away of the two-pole dynamo for work above a certain figure, and the struggle between quickly revolving and slowly revolving engines, are all represented, the speeds ranging from 85 revolutions per minute up to 550, with varying speeds between. Further, the Exhibition plant proclaims the death of belt and rope driving for central station work.

The plant consists of—

One Willans engine, triple crank, with a complete triple-expansion engine over each crank, the cylinders being respectively—



ENGINES BY MESSRS. WILLANS AND ROBINSON DRIVING COMPOUND-WOUND DYNAMOS BY MESSRS. CROMPTON AND CO. AND THE BRITISH SCHUCKERT CO.

the high-pressure 15 ins. diameter; the intermediate 23·6 ins. diameter, and the low-pressure 37·5 ins. diameter, with a stroke of 17 ins. The three cranks are arranged at angles of 120 degs. with each other, and the weights of the three moving sets are exactly alike, so that vibration from uneven turning moments is reduced to a minimum. The three sets of cylinders are mounted vertically, tandem fashion, in the now well-known manner of Messrs. Willans & Robinson's engines. The engine weighs 34 tons, and is designed to furnish 1,200 h.p. when supplied with steam at 180 lbs. pressure and working with a condenser. The engines at the Exhibition are exhausting into the atmosphere. The valve gear is of the usual Willans central type, in which the piston rod itself, made hollow for the purpose, carries the valves as well. The engine is directly coupled to a Crompton compound-wound dynamo, arranged to furnish 1,320 amps., at 550 volts, when running at 230 revolutions per minute, and to furnish an overload of 50 per cent. for a short time when required.

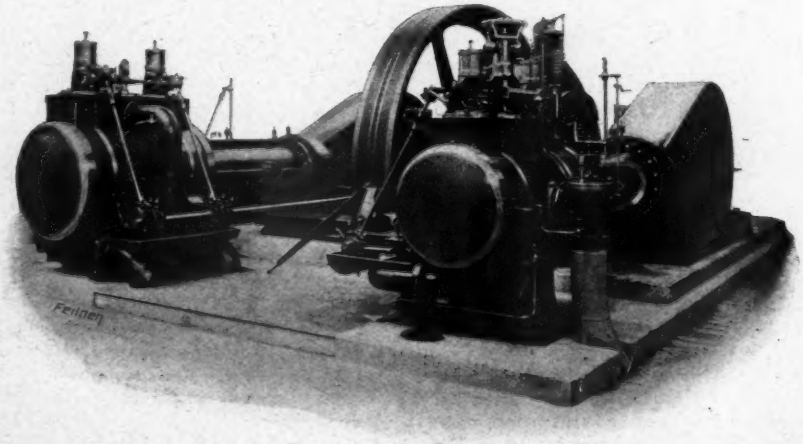
One similar Willans engine in every respect, directly coupled to a Schuckert compound-wound dynamo, arranged to furnish exactly the same current and pressure, at 230 revolutions per minute, as the Crompton machine, and to meet the 50 per cent. overload similarly to that machine.

The Willans engines have a special arrangement for meeting the overload, as follows:—By-pass valves, which can be worked by hand or by the governor as desired, are arranged to admit full boiler pressure into the intermediate cylinder during the period of overload, so that the

intermediate and low-pressure cylinders have their mean effective pressures raised for that period, and are therefore enabled to perform more work for the time. It is claimed that this arrangement is simpler and more economical than an alteration of the cut-off, and can be applied very much more quickly.

One Robey cross-compound horizontal engine directly coupled to an eight-pole compound-wound dynamo, made by Messrs. Mavor & Coulson, of Glasgow. The engine cylinders are, high pressure 20 ins. diameter, low pressure 35 ins. diameter, stroke 42 ins.; and it is designed to give from 500 to 550 indicated h.p. with 150 lbs. steam pressure at the stop valve when running at 85 revolutions per minute. A heavy flywheel is attached to the end of the crank shaft, and to a centre boss on the flywheel the corresponding boss on the end of the armature shaft of the dynamo is bolted. The dynamo furnishes a current of 636 amps. at a pressure of 550 volts when running at the speed mentioned. It is claimed that this is the largest dynamo yet made in Scotland. The dynamo is of the same type as those exhibited by Messrs. Crompton and the British Schuckert and other companies, and, as arranged, it will be seen that the armature forms part of the flywheel of the engine, or, as it may be termed, an extension of it. This set is the slowest-speeded set exhibited, marking the extreme on that side. The Robey engine is controlled by Richardson's electric governor, which is arranged to admit steam to the cylinders for from 0 to ·60 of the stroke. The apparatus consists of a pair of solenoid coils, connected in shunt across the armature of the dynamo it is controlling, the solenoid cores being connected with the bar which controls the time during which the steam ports are open. In case of a short circuit on the cables fed by the dynamo that is under regulation the solenoid is automatically put out of action, and the valve is closed by the falling of a brass bar attached to the solenoid cores, which operates a lever arranged to shut off steam by closing the entry valve.

One Davey-Paxman cross-compound horizontal engine, directly coupled to a dynamo made by the Electric Construction Co. The engine is of the type called by the makers their improved horizontal electric traction engine, and forms the subject of the presentation plate. It is designed to furnish 650 b.h.p., when running at 150

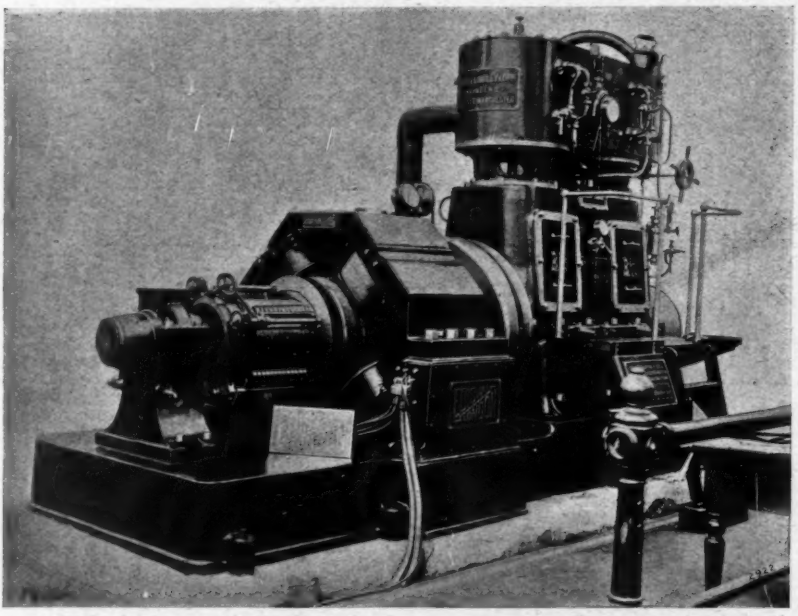


EIGHT-POLE COMPOUND-WOUND DYNAMO BY MESSRS. MAVOR AND COULSON, DRIVEN BY A ROBEY CROSS-COMPOUND ENGINE.

revolutions per minute. The cylinders are 15½ ins. high pressure, 27 ins. low pressure diameters, with 30 ins. stroke. Expansive gear is applied to both high and low pressure cylinders. Messrs. Davey, Paxman & Co., claim that the static deflection of the centre of the shaft is only ·008 in., so that there should be no danger of trouble with the armature rubbing on the pole pieces. The dynamo is designed to furnish 500 volts and 600 amperes, at the speed named. It is of the usual ring type, with eight poles, the ring-yoke being of cast iron of elliptical section, and the magnet cores being of sheet steel plates cast in solid, and wound with pyramidic winding. The armature is connected mechanically to the end of the crank shaft of the engine, and is built up of their charcoal plates upon a substantial drum, the armature in fact forms part of the fly-wheel of the engine and runs between the two cylinders, though the engine also carries a heavy fly-wheel.

One triple-expansion Belliss engine directly coupled to a Bruce-Peebles dynamo, the combined set running at 400 revolutions per minute, and furnishing a current of 380 amps. at 550 volts. The engine is of the enclosed type, double acting, the governor controlling the throttle valve. The dimensions are—high-pressure cylinder 12 ins., intermediate cylinder 17 ins., low-pressure cylinder 24 ins. diameter, by 10½ ins. stroke.

One enclosed, quickly revolving compound-engine, directly coupled to a four-pole dynamo, both made by Messrs. Ernest Scott & Mountain. The engine is of the vertical type, the high-pressure cylinder being 11¼ ins. diameter, and the low-pressure cylinder 20 ins. diameter, by 10 ins stroke, and designed to furnish 240 b.h.p. at 360 revolutions per minute, with 140 lbs. steam pressure at the stop valve. The dynamo is compound wound, and is designed to furnish 640 amps. at 250 volts, at

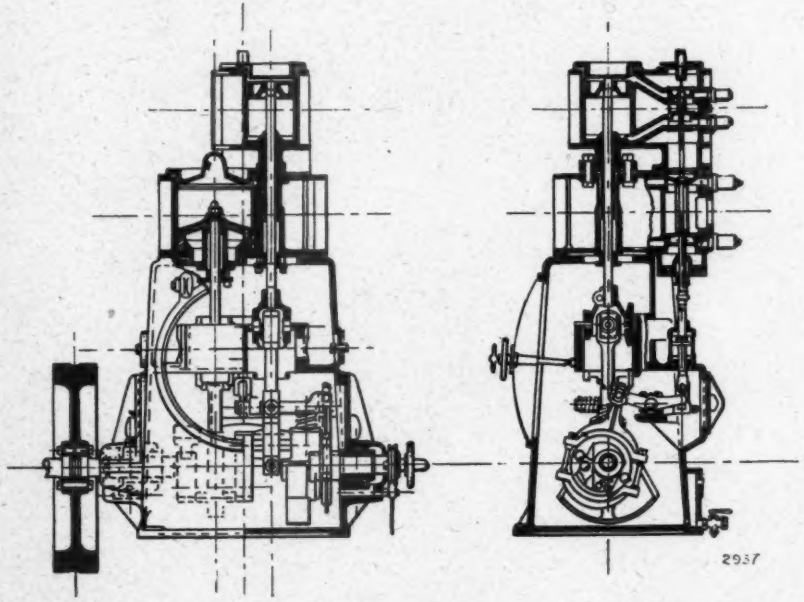


EDI-SWAN DYNAMO DRIVEN BY A BROWETT-LINDLEY ENCLOSED VERTICAL COMPOUND ENGINE.

the speed named. The engine and dynamo are mounted together on one bed-plate in the usual manner, both cylinders being over the crank chamber, and the steam entry valve being between the two, and of the piston type, one valve controlling the supply of steam to both cylinders. All bearings are fed with oil under pressure.

One Alley & McLellan compound vertical three-crank engine, the cranks being set at 120 degs. apart, as usual in these cases, directly coupled to a six-pole dynamo made by Messrs. Mavor & Coulson, and designed to furnish 680 amps. at 250 volts, when running at a speed of 400 revolutions per minute. The engine cylinders are—high pressure 10 ins. diameter, low pressure 18 ins. diameter, by 9 ins. stroke. The engine is of the single-acting type. In this case the usual combination base plate is not used for mounting the engine and dynamo, but three cast iron anchor plates are built into the foundations for carrying the magnets and the outer bearing of the dynamo. It is claimed that this arrangement allows greater freedom for getting round the machine, and that it also admits of a freer access of air to the armature of the dynamo.

One Browett-Lindley enclosed vertical type compound engine directly coupled to a dynamo of the Edison-Swan Co. manufacture, the dynamo being designed to furnish 520 amps. at 250 volts, when running at 380 revolutions per minute. The dynamo is shunt wound and is guaranteed to have an efficiency of 94 per cent. at full load, and 91 per cent. at half load. A dynamo with this efficiency at half load should be of service for general industrial work, as distinguished from central station work. With central station supply work, economy dictates that the machines shall be worked at as near full load as possible; with general industrial work, the supply of current for light and power to works of all kinds,



DETAILS OF THE SISSON'S VERTICAL COMPOUND ENGINE WHICH DRIVES A CLARKE-CHAPMAN DYNAMO.

economy dictates that the plant shall be worked at as low a percentage of possible full load as can be arranged. The engine cylinders are—high pressure 13 ins. diameter, low pressure 21 ins. diameter by 9 ins. stroke. There are two cranks, the two cylinders being arranged side by side. The governor is of the shaft type, acting directly on the throttle valve.

One Sisson's vertical type compound engine, directly coupled to a Clarke-Chapman two-pole dynamo, designed to furnish 400 amps., at 250 volts, when running at 400 revolutions per minute. The cylinders are—high pressure 9 ins., low pressure 15 ins., by 9 ins. stroke. The special feature of this engine appears to be the fact that the makers have arranged to have two cranks, very close together, on the one crank shaft; and this is accomplished by placing the high-pressure cylinder above the low-pressure, but only partly in the same vertical line, so that the connecting rod of the high-pressure piston comes very close to the low-pressure cylinder. The engine is double acting. It is claimed that the arrangement of the crank lessens the vibration by giving a more equal turning moment, and also lessens the twisting strain on the crank-shaft itself.

One Robey vertical type enclosed compound engine, directly coupled to a two-pole generator, made by Ernest Scott & Mountain, and designed to furnish 200 amperes, at 250 volts, when running at 550 revolutions per minute. The engine cylinders are—the high pressure 8½ ins. diameter, low pressure 14½ ins. diameter, by 6 ins. stroke; and the engine is designed to furnish 100 i.h.p. when running at the speed named. The engine is fitted with a system of forced lubrication, the oil pump being worked by the eccentric, and the oil being forced through all the working parts at a pressure of 15 lbs. per sq. in. The governor is of the throttle type, with an arrangement for adjusting the supply of steam to the high-pressure cylinder according to the load.

Another Robey engine of the vertical type, compound, but with open front, directly coupled to a four-pole dynamo by Ernest Scott & Mountain, designed to furnish 200 amps. at 250 volts, when running at 250 revolutions per minute. The engine cylinders in this case are 10½ ins. and 18½ ins. respectively, by 11 ins. stroke, and it is designed to give 100 i.h.p. when running at the speed named, and supplied with steam at 150 lbs. pressure at the stop-valve. The consumption of steam is stated to be 26 lbs. per i.h.p. at full load.

One Ruston-Proctor vertical compound double acting engine, directly coupled to a C. & C. four-pole dynamo, designed to furnish 320 amps. at 250 volts, when running at 450 revolutions per minute. The engine cylinders are—high pressure 9½ ins., low pressure 15 ins. by 8 ins. stroke, and the maximum brake horse-power at the given speed is 100.

There is also a motor balancer, made by Messrs. Bruce-Pebbles & Co. of Edinburgh, designed to deal with 100 amps. out of balance; it runs at 1,000 revolutions per minute.

The total possible electrical energy that could be taken from the generating station, as will be seen, is 4,270 amps. at 550 volts, and 2,885 amps. at 250 volts, or the equivalent of approximately 5,700 amps. at 550 volts, or 3,069 kilo-watts. The maximum load the station has had to deal with has not exceeded 1,100 amps. at 500 volts, while the smallest load has been 150 amps. at 500 volts, or 550 kilo-watts and 75 kilo-watts respectively, from which it will be seen what a very wide margin has been maintained in the generating station over and above all possible requirements. The Exhibition, as already indicated, has been treated as a town of at least 100,000 inhabitants given to congregating at certain points towards closing time, and the effect upon whom of an extinction of the light of even a very short duration would be very serious indeed.

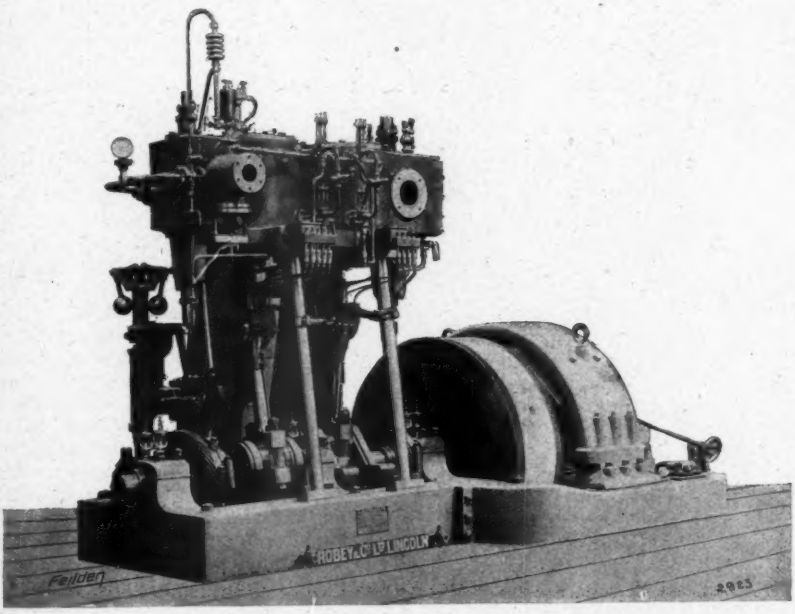
In addition to the above, current is generated at some of the stalls, as will be described.

THE MAIN SWITCHBOARD.

From the generators the current is taken to the main switchboard, made by Messrs. Kelvin and James White, of Glasgow, a view of which is shown, and which is

situated in a convenient position close to the generators, but where it can be seen by all who are interested in the matter. The main switchboard is also arranged as for a town that is being supplied with current for light and power purposes on the three-wire system, the pressure between the outers being from 500 to 550 volts. The switchboard consists of marble panels, of which there are 21, each panel being made up of two marble slabs, the whole built up on a framework of angle-steel, which also forms one side of the framework of the shed attached to the stall, in which all the connections at the back of the switchboard are made. There are 12 machine panels and eight feeder panels to each machine panel, the top slab in each panel being the positive and the bottom slab the negative, the top slab carrying a Kelvin recording ampère and volt gauge and a main switch of the Kelvin pattern, having carbon breaks, and having the principal contacts of copper arranged to engage with each other edgewise. The bottom slab carries a Ferguson & White's automatic return output, with arrangement for blowing out the spark formed on breaking circuit. It also carries the field circuit regulator, which is of the usual hand-wheel type, and a pair of sockets for connecting the Kelvin paralleling voltmeter.

The feeder panels are also arranged with the top slab positive and the bottom slab negative. Each slab carries a switch similar to the positive machine switch. The neutral panel carries an ampèremeter showing any current passing through the neutral wire, an earth current recorder, an automatic cut-out on the earth connection in case the leakage current is above a certain figure, and an ampèremeter, which is put into circuit when the earth current recorder is cut out; two recording voltmeters, one on each branch, and two



OPEN-FRONT VERTICAL ROBEY ENGINE COUPLED TO AN ERNEST SCOTT AND MOUNTAIN DYNAMO.

multicellular voltmeters, one on each branch. It also carries four voltmeter switches, to connect any machine to any voltmeter.

Above the board are two voltmeters, reading to 600 volts for the 500 volts service, and two voltmeters reading to 300 volts for the 250 volts service, and a clock electrically controlled from a regulator at Messrs. Kelvin & White's stall in the Grand Avenue. The recording ampèremeters on the feeder circuits are also controlled from the same regulator.

THE BALANCER SWITCHBOARD.

The balancer switchboard is close to the main switchboard, and consists of two enamelled slates held in a frame of polished wood, carrying each an ampèremeter reading to 120 amps., a three-contact switch and three fuses, and a regulating switch of the usual type. The current for the balancer is taken from the bus bars.

All the resistances for the main switchboard and for the balancer are carried behind their respective boards. In the case of the main switchboard it will be seen that there is plenty of room for the attendants to get about, and to make and break connections as may be necessary without receiving shocks.

THE ARC LIGHTING SWITCHBOARDS.

These are fixed in different parts of the building and are all arranged as follows. Each board is of enamelled slate and carries connections for 16 circuits. It also carries one main switch arranged to break circuit or to connect to the Corporation supply, and 16 double pole switches with three-inch break, and 16 fuses, also a main fuse. The electric clock and the recording ampèremeters are worked by a relay in the shed behind the main switchboard.

THE RIVAL ILLUMINANTS.

As indicated in the first article of this series, the position which electricity has assumed is challenged by improved forms of the older agents. In the domain of lighting these are, for outdoor lighting, ordinary town gas forced through Welsbach mantles at a much higher pressure than is usually employed for this purpose, and an oil gas made by a special process, also forced through the Welsbach mantle under pressure. For indoor lighting, acetylene gas is well to the fore, there being no less than three exhibitors of apparatus for making it. There are also two exhibits of oil gas, one by the Patent Paraffin Gas Lighting Co., who show a plant for the manufacture of gas from paraffin oil for private houses; and the Notkin lamp, which was alluded to in the preceding article, all of which claim to be better and cheaper than the incandescent electric lamp. Of these, the Notkin appeals to private householders, and to those who like a soft steady light in their offices but who are not situated where there is a convenient and cheap electrical supply service. The Notkin lamp is a portable petroleum lamp, in which the vapour of the oil is burnt in the lamp, but without the necessity of a wick or chimney. The apparatus, photograph of which is shown, consists of a reservoir for the petroleum, but in place of this being, as usual with petroleum lamps, underneath the burner, it is placed above it, and the oil is held in the vessel, in the pores of a spongy substance placed there for the purpose, such as wood felt, infusorial earth, and other substances. Only as much oil is placed in the reservoir as the absorbent will take up. From the reservoir a pipe leads to the burner, which is of the ordinary pattern, with the usual tap. Another pipe also leads to the top of the reservoir, with a tap, the opening of which admits air to the top of the reservoir. The vapour of the oil as it passes from the absorbent is of specific gravity ·650 to ·680. The oil vapour only passes into the pipe leading to the burner, when air is allowed to enter the reservoir, so that all danger of escaping gas is done away with so long as the air tap is closed. There is not any necessity to refer to acetylene, farther than to mention that the utmost claim on the score of cost, made by makers of apparatus for acetylene gas, is that, with ordinary town gas at 2*s.* 9*d.* per 1,000 cubic feet and upwards, acetylene gas is cheaper. In connection

with this it should be noted that with calcium carbide at its present price, 22*s.* per cwt., the cost of lighting, allowing fully for the fact that a very much smaller quantity of acetylene is used for the same illumination than of coal gas, is at the rate of 4*s* per 1,000 cubic feet of coal gas, leaving out all charges for attendance and all interest and depreciation of plant. It should be understood that in each case a plant of some kind has to be laid down and attended to, if light is required, with the single exception of the Notkin lamp.

With reference to this and the competition with the incandescent electric lamp, it should be mentioned that electricity at 3*d.* per unit is equal in cost to gas at 2*s.* 6*d.* per 1,000 cubic feet, and that current is being supplied to the Exhibition by the Corporation of Glasgow at 1½*d.* per unit; while the probability is that incandescent lamps, of the Nernst and similar patterns, which are just being placed on the market, will take about one-third of the current taken by the present electric incandescent lamps for the same light at the same pressure, and that the cost of generating electrical energy will steadily decrease. In Chicago and other American towns they are generating at ½*d.*, and less, per unit, without the advantage of cheap coal or water power.

The principle upon which the undoubted advance has been made in out-door gas lighting is, the gas is forced through the Welsbach mantles at from four to five times the pressure usually adopted, this having the effect of drawing through a proportional quantity of air, so that a very much larger and more complete combustion takes place, with the result that a higher temperature of the carbon particles that are arrested by the meshes of the Welsbach mantle is obtained, a better light following with a smaller consumption of gas; added to which the gas companies will score again on the side of cost, as the gas which gives the best results in this high-pressure process is heating gas and not illuminating gas as ordinarily understood; and heating gas is cheaper to manufacture than illuminating gas.

With the town supply gas the higher pressure is obtained in two ways, as illustrated in the grounds of the Exhibition. The gas itself is compressed by a machine provided for the purpose by the Water Motor & Automatic Liquid Elevator Company, which is shown in operation, and delivered to the lamps in the grounds by means of pipes from the compressor.

THE "NOTKIN" LAMP.

The other plan is that exhibited by the Scott-Snell Company, in which the com-

pression is performed in the gas lamp itself.

The Water Motor Company's apparatus consists of a pair of compressors worked by a water motor of special construction, arranged to work with very slight friction, and therefore to consume a very small quantity of water, the speed of the compressor and the quantity of gas compressed being automatically controlled by the gas holder itself. The town gas is admitted to the compressor at 1½-in. water gauge, say 7·8 lbs. pressure per sq. in., and it is compressed up to 8 ins., or 41·6 lbs., or to a higher pressure if desired, at which pressure it is delivered to the service. It will be seen that though this apparatus is beautifully simple and works well—the present writer watched it for some time—it necessitates two things—the compressing plant and a separate service of pipes for distributing the high-pressure gas. For the Exhibition grounds this does not matter, as pipes had to be laid down specially in any case, and it was just as easy to lay down pipes for the higher pressure as for the lower pressure. For ordinary everyday work, however, the question arises how far this would be feasible. It is true that a separate service of pipes for the street lighting could be laid down to take the high pressure gas; but, again, it may be doubted how far it will be possible to increase the number of pipes under the roadway. To obviate this necessity the Scott-Snell apparatus has been worked out. It consists virtually of a compressor worked by the heat of the lamp itself. Welsbach mantles are used, as with the other apparatus, and a compression chamber is carried right over the mantles. Inside the compression chamber is what is practically a floating piston, connected mechanically, by a vertical rod, with a diaphragm and a spiral spring, the latter being capable of adjustment. When the lamp is not burning, the piston, which the inventor calls a displacer, rests in the middle of the compression chamber, in that position closing the connection between the supply pipe from the town service and the reservoir of compressed gas The burner is fed from the reservoir, into which the gas is forced as it is compressed. The lamp being lighted heats the chamber above it, the compression chamber, and in doing so forces up the displacer, as the inventor calls it, and with it the diaphragm to which it is connected, compressing the spiral spring controlling it. Above the compression chamber is a water chamber, which, with the pressure of the spiral spring and the pressure of the atmosphere on the diaphragm, causes the displacer to fall. The displacer keeps up this alternate rising and falling as long as the lamp is burning, compressing and delivering the compressed gas into the reservoir in the process, from which it passes to the lamp. A number of the lamps in the grounds are fitted with this apparatus, and also work very well. The only objections appear to be that the diaphragm moving up and down makes a noise that would be unpleasant in a room, but which does not matter out of doors, and that the lamp takes a certain time to get into operation.

The Kitson apparatus consists of a reservoir of petroleum, to which is attached a compressed air chamber, together with a pump. The reservoir is filled with oil, and the air is compressed to 45 to 50 lbs. per square inch. From the reservoir a small pipe, about ⅛ in. in the bore, is carried to the neighbourhood of the burner. The burner is again a pair of Welsbach mantles. Over the mantles is a small tube, through which the oil from the reservoir passes, and in which it is converted into vapour by the heat from the mantle. From the gasifier, or carburettor, the heated tube just described, the vaporised oil passes through a mixing tube, where it is mixed with the necessary quantity of air for combustion, and from this mixing tube a small pipe passes to the Welsbach burners in the usual manner. When the lamp is first lighted the petroleum in the vaporising tube is cold, so a method has to be arranged for supporting combustion and providing the heat required to start the vaporisation. This is arranged in two ways. In that most in favour with the inventor, and in use at the exhibition, a small tank of petrol, similar to that used for autocars, is carried in the base of the lamp pillar with the oil reservoir, from which

a pipe is led to the Welsbach burners, and the petrol from this tank supplies the heat required, it being ignited by means of a wire, carried in the lamp over the burners, which is heated by means of an electric current from a portable battery taken round by the lamp lighter. As soon as the heat in the vaporising tube is sufficient for the working of the lamp the petrol supply is automatically cut off. To extinguish the lamp the supply of petroleum is cut off by a tap at the base of the pillar, but the lamp does not go out till the whole of the petroleum that has been vaporised up to that moment has been consumed. The lamp is also fitted for inside use, and the Russian Pavilion is brilliantly lighted with Kitson lamps, which are fed from reservoirs placed in convenient positions, eight lamps being fed from one reservoir, and the tube required for the eight being only $\frac{3}{8}$ in. in diameter, while that for one lamp is only $\frac{1}{8}$ in. diameter. The great advantage of the system for outdoor lighting is the fact that the apparatus is self-contained, the reservoir, lamp, and all accessories being contained in the lamp-post itself, the reservoir occupying the usually vacant space in the base of the pillar. For indoor lighting this advantage is not so apparent, but again the apparatus renders the factory independent of everything except a supply of oil and petrol, and the arrangements for ignition. The disadvantages are, the fact that the reservoirs require to be filled and the compressed air pressure brought up to a certain figure every day, and the fact that the lamps do not light instantaneously, as do gas and electric lamps, though it appears to the present writer that this could be overcome by a judicious employment of electricity.

And now as to the claims put forward by both the high pressure gas systems and by the Kitson system, that the light is superior to that furnished by the electric arc light, that it is cheaper, and that it is more nearly like sunlight. The present writer made careful tests on these points. With regard to the first he found the ratio between the light given by the several lamps to be as follows:—The arc light, 225; the large lamp exhibited by Messrs. James Keith & Co., in which three Welsbach mantles were employed, 196; the ordinary high-pressure gas, in which two Welsbach mantles were used, 169; and the Kitson from 64 to 121. In taking these ratios it should be borne in mind that while the gas and oil lamps were all fitted with clear glass lanterns and with reflectors above the burners, the arcs were all fitted with opal globes, which absorbed considerably more of the light rays than the others.

For the purity of light test the writer is indebted to Mr. W. M. Gardner, of the Municipal Technical School of Bradford, who, with Mr. Dufton, has made a number of experiments on the subject. Mr. Gardner was kind enough to send the writer some fabrics, which had been woven specially for the purpose, in which if the light by which the fabric was viewed contained an excess of red rays, as artificial lights usually do, a portion of the fabric showed a different colour to that shown by daylight. The test was so delicate that even in daylight some lights showed the difference, particularly reflected light inside a room. All the lights showed the presence of an excess of red rays, but the Kitson appeared to contain less than any of the others, not excluding the arc lamp. With regard to the relative cost of the several forms of light for outdoor use: for practical purposes, it appears to the writer that either the high-pressure gas lamp using two Welsbach mantles, or the Kitson lamp, using the same number, should be taken as equal to the arc lamp, since, though they do not actually give the same candle power, they give practically the same illumination, say, for street or village road lighting. Taking this as a basis, and taking the consumption of the three agents, and with gas at 2s. 6d. per 1,000 cubic feet, the high-pressure gas comes out at $\frac{6}{10}$d. per lamp per hour; the Kitson, as claimed, $\frac{3}{4}$d. per hour; and the arc lamp at the price charged by the Glasgow Corporation, $1\frac{1}{2}$d. per unit, $\frac{3}{4}$d. per hour. These figures do not include the cost of attendance on the lamps, of the carbons for the arc lamps, nor of the mantles for the gas and oil lamps. It may be said, therefore, that the cost of

the three would be approximately the same, and the illumination about the same for practical purposes. It should be remembered, however, that while gas appears to have reached its limit in the matter of cost, electricity has by no means reached its lowest figure. The figure charged by the Glasgow Corporation, though it is low as compared with the cost in many towns, by no means represents the figure at which electricity can be produced. Added to which electrical engineers are daily looking for improvements in the direction of the Nernst and other forms of electric lamps, which will again bring down the running cost. Anything which will enable an incandescent electric lamp to be run at an efficiency of 1 watt per candle, with a charge per unit not exceeding one penny, will put the high-pressure gas and high-pressure oil gas out of the running; and both of these are only questions of time. In the writer's opinion, the place for the consumption of gas, whether made from oil or from coal, is in the cylinders of the engines that are driving electrical generators, except in special cases where it will not pay to lay down plant for generating electricity. The writer desires to acknowledge the courtesy of Mr. Berwick Millar, the Superintendent of Gas Mains for the Corporation of Glasgow, who kindly put him in the way of obtaining full information *re* the gas services. Mr. Millar claims that gas has knocked out the electric light in the contest.

SYDNEY F. WALKER.

Machine Tools at the Glasgow International Exhibition.

By JOHN ASHFORD, M.I.Mech.E.

DID you see our engine when at the Glasgow Exhibition? asks a friend.

No.

Why, how was that? Surely you walked all through the Machinery Hall?

No, again, for my visit was to look at the machine tools, and I saw them. If you wish to know anything about those we will talk, but as for engines, it will take another visit to see them.

It is rather a good idea, that—to have an elevated gallery from which the visitor may obtain a bird's-eye view of the hall, note the thing he wishes to see, and make a bee-line for it.

New things? Yes, a few, and old things somewhat modified and served up afresh. It is good to see new things, but better, much better, to see older things, those which have a familiar look about them, improved, modernised, bearing the appearance of sound improvement and development.

For several years past there has been rather a craze for new machine tools of novel construction, with little trickinesses that form good talking points, and perhaps save a little labour or time. Such a craze is good, as it has its uses, for although it brings out some rubbish, it also brings forth sufficient in new types of machines to mark a decided step forward, and it also stirs up the conservative, engendering the doubt as to whether they have found rock-bottom, or that their machines were all that could be desired. Doubt produces thought, and thereby the door is opened for sound improvement.

Could the British type of lathe-bed be improved? Altered, most certainly, but improved, never, was said, some ten years ago, and yet we find a substantial firm like Messrs. John Lang & Sons staking their good name on a new design of that detail. A big risk, but justified by careful experiment and anxious trial, with promise of certain success.

Why alter that which was good enough? *Good enough?* That which *was* good enough a few years ago must give place to the better *now*.

Tried the machine? Certainly, and found it all right. The saddle is gibbed to a comparatively narrow strip-like projection raised on the surface of the bed, while the back of the saddle rests upon a broad, flat surface. A good point, is that the tailstock takes its alignment from a raised half **V** that is cleared by the saddle.

It is at the Exhibition, this lathe-bed—several of *it*, in fact—and much room is taken thereby on Messrs. Lang's stand. Ordinary turning lathes there are, 6 ins., 8 ins., and 12 ins., sliding, surfacing, and screw-cutting; a shell-turning lathe with duplex saddle, and a 24-in. chucking lathe for surfacing and boring, all with this patent bed.

But that shell-turning lathe—one turns to look at it again. A fine machine, and well proportioned, taking the eye immediately as a good thing; so evidently thought the manager of a large ordnance factory, for no sooner was it seen than 24 were bought. The shape of a shell is parallel on the body, excepting for a gas ring, and the nose is struck to a radius. This shell-turning lathe has two saddles, one for traversing the parallel part, and the other with radius bar attached to a movable fulcrum at the rear for striking the curved portion. The new style of bed lends itself well to this arrangement, for the raised portion to which the saddles are gibbed is made to pass alongside the fast headstock,

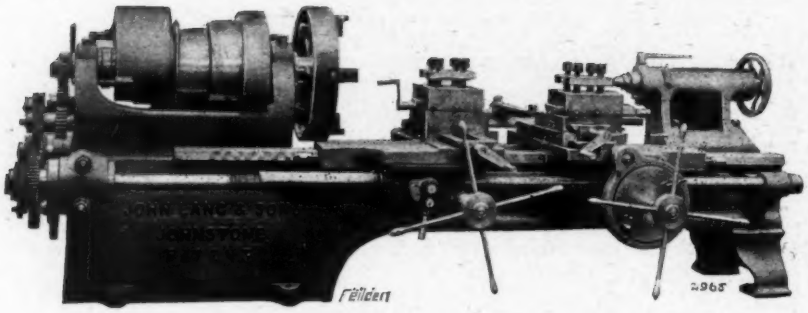


FIG. 1.—SHELL-TURNING LATHE BY MESSRS. JOHN LANG AND SONS.

thus allowing the limb of the first saddle, arranged left-handed, to traverse in front thereof, so that the cross slide with the slide-rest, gets well home to the centre. There is the further advantage in the right and left arrangement of the saddle limbs, that the two tool-holders can be brought into close proximity to each other.

A glance at the reproduced photographs, Figs. 1 and 2, will make this duplex arrangement of saddles quite clear to the reader.

Can we say that the idea of putting a pair of saddles with the necessary tool rests, to turn the two portions of the shell at one time, is good as compared with the previous method of first turning the body in an ordinary lathe and then chucking it in a second machine to turn the contour forming the point? The question seems superfluous.

As regards the details. Two tools simultaneously taking heavy cuts on steel require plenty of belt power, to meet which there is a two-step cone for a 5-in. belt and treble back gear. Pull through anything!

Friction headstock? No! this is not a turret lathe, but a one-job machine, made to turn shells. It certainly could be used for other work, but that is not the prime intention.

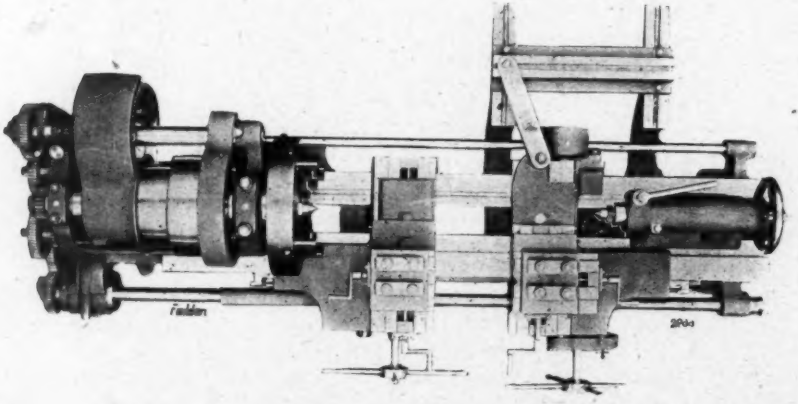


FIG. 2.—TOP VIEW OF SHELL-TURNING LATHE.

Ample bearings there are, with a good stiff spindle; a loose headstock well buttressed at the back to stiffen it against the thrust from the tools, taking its alignment from a portion of the bed not touched by the saddle; and independent traverse for each of the two saddles.

As the machine is to be continuously occupied upon one class of work, there is no special arrangement of change gear for varying the speed of traverse.

Before leaving Messrs. John Lang & Sons' stand we might pause to look over a turret lathe (Fig. 3), which they have designed for working up castings that can be held in a chuck of 24 ins. diameter and clear in a machine with a 34-in. swing, such as cylinder covers, piston valves, bonnets, stop-valve bodies of large size, etc. Many such castings require to be both bored and faced, and for that purpose the turret is mounted upon a saddle with compound slides, having power feed for both surfacing and traversing. The speed of feed is variable by six steps as follows: 160, 80, 32, 20, 10, 4 cuts per inch for both surfacing and boring. To obtain the series of changes without the handling of gears, Lang's patent double-handled feed motion, now so well known, is introduced.

A lathe of this kind requires rather a large range in the speed of its revolutions, and it is desirable that the workman should be able to quickly change from one speed to another, in order that the actual cutting speed may be kept up to its maximum when taking a surfacing cut. To facilitate this desirable quick change, friction back gear is introduced. That, together with two speeds on the countershaft, gives four changes by handle movements with one position of the driving belt upon the step cone. The turret has six sides, and upon them tool-holders are mounted, into which ordinary boring and turning tools may be fitted. It has already been stated that there are compound slides to the saddle, thus, an ordinary lathe hand can set the tools without the assistance of a special tool-maker.

To facilitate repetition work, a set of six

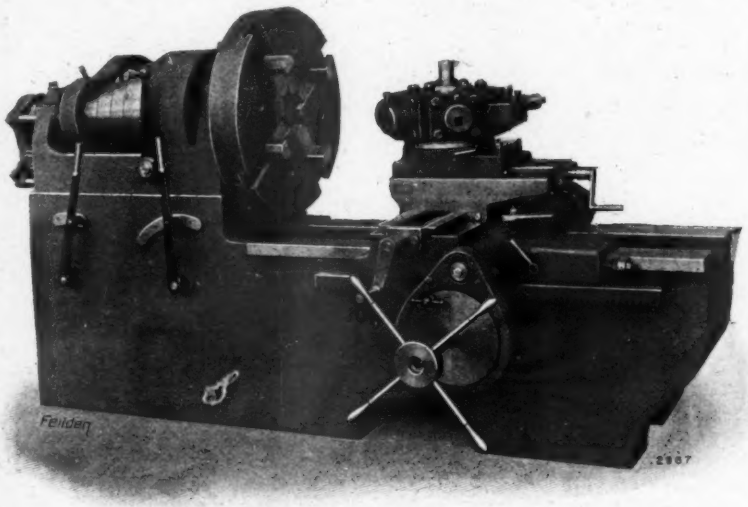


FIG. 3.—SURFACING AND BORING LATHE BY MESSRS. JOHN LANG AND SONS.

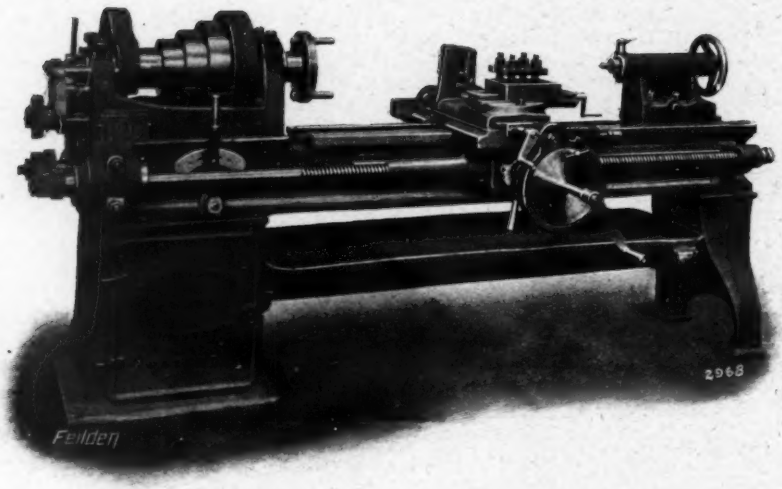


FIG. 4.—SCREW-CUTTING LATHE BY MESSRS. JOHN LANG AND SONS.

stops is fitted to both the cross slide and the saddle, and these have to be rotated by hand, to correspond with the tool in action on the turret. This fact would tend to open the door for a careless person to get a wrong stop into position and spoil the work.

If these stops could be made to change with the rotation of the turret it would be a decided improvement; at the same time, it must be confessed that it would be an awkward matter to arrange in connection with a turret mounted on cross slides.

Perhaps the point that should be clearly made about this machine is that the turret supplements the compound rest, and that ordinary turning and boring tools are used, dispensing with costly tool outfits.

There is no attempt here made to provide a machine that shall bring a number of cutting tools into action at one time.

Dispensing as it does with expensive tool outfits, it can be economically used upon single castings, and for eight or ten of a sort it would be more economical than other machines requiring expensive tools.

In the earlier days of turret lathes we became familiar with a type of machine that was specially built for making all kinds of screws and bolts, its chief use being to turn and screw bolts that had forged heads. To admit of the introduction of the forged blank, the spindle was made of large diameter, hollow through its centre, and with its sides cut away, leaving an opening between the poppets for the introduction of the bolt.

Messrs. Lang & Sons are exhibiting a modernised machine of this type, having a turret carried upon a saddle with a cross slide, and a folding-over screwing-head hinged to the back of the saddle, so that it can either be pushed out of the way or brought over into position for screwing. The chasers, which form the die, are made of bar steel, and so fitted in the die head that there is no difficulty in screwing up to a shoulder.

Of the other lathes exhibited by this firm, it suffices to say that they are good examples of a well-made stiffly-built British type of machine, newly designed, with improvements in those small details which affect the working qualities and life of a machine. (See Fig. 4.)

The more recent systems of organisation in the workshop have called new machines into existence, whose object is to avoid loss of time in the handling of work. Centring machines and arbour presses are of this nature. Much time may be lost by the lathe hand in square centring his work and drilling it up, especially if he does it upon his lathe in the old-fashioned way. A comparatively inexpensive centring machine, which may be worked by a boy, will quickly save its own cost in the average machine shop. (See Fig. 5.) The usual thing in a centring machine is to have one spindle with a counter-sinking drill, and a suitable vice to bring the work into correct position. The machine on this stand is provided with two spindles, carried in a head mounted upon a cross slide, with stops, so that when it is moved by a handle to its extreme positions, either front or back, one or other of the two spindles is truly central with the holding vice. The spindle, which is supposed to be first brought into use, has a cutter which faces off the end of the work, leaving it square and ready for the centring drill, which is next brought into action in the second spindle. The point here, is, that as the end of the work is first faced, there is little likelihood of the centring drill being broken, and the work has a clean end when turned.

A neat little grinding machine for sharpening such things as twist drills, rose bits, taps, cutters, taper reamers, and angle cutters is also exhibited by this firm, and it would be easy to demonstrate the successful application of the machine to sharpening each of the kind of tools named.

There is a bold originality about the buffer turning lathe exhibited by Messrs. P. & W. Maclellan which appeals to one at once. The buffer-face has to be turned to a suitable radius, and it is in the method of obtaining this radius that the more especial smartness of this machine comes in. To get the required curvature

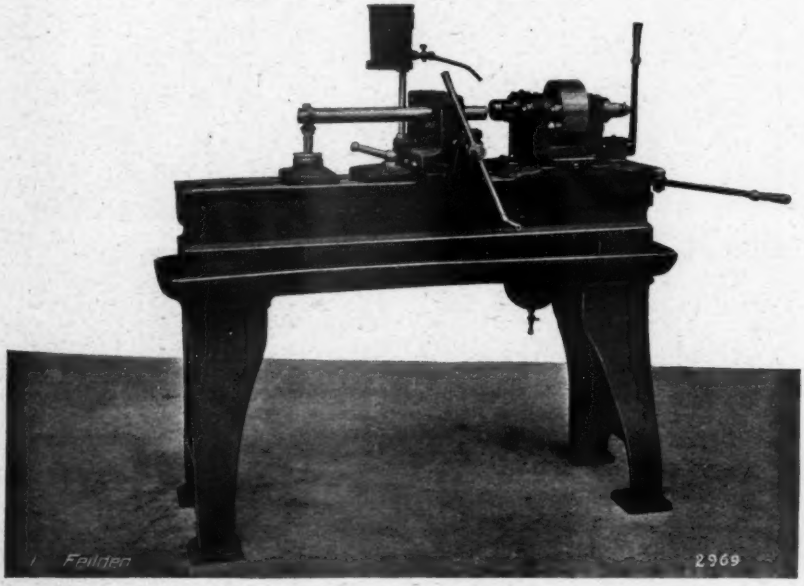


FIG. 5.—BORING MACHINE BY MESSRS. JOHN LANG AND SONS.

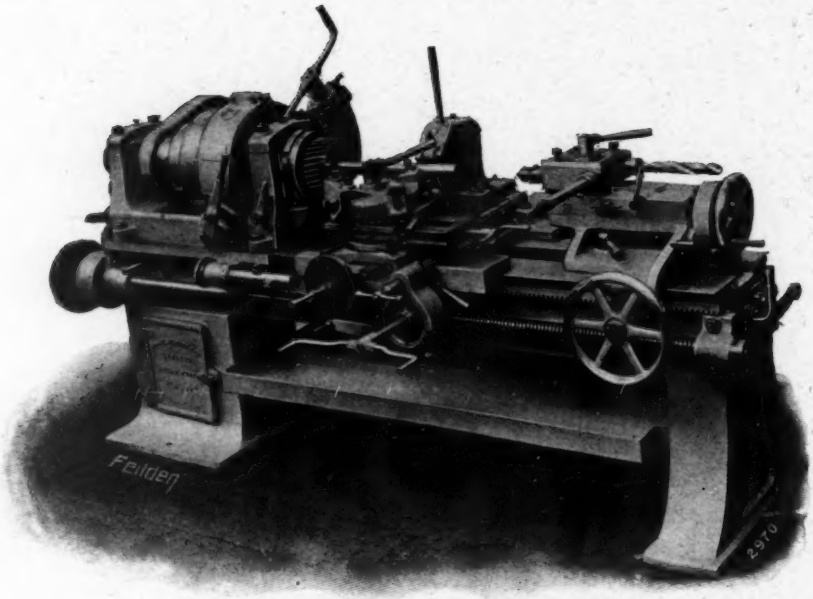


FIG. 6.—TURRET LATHE BY MESSRS. SHARP, STEWART AND CO.

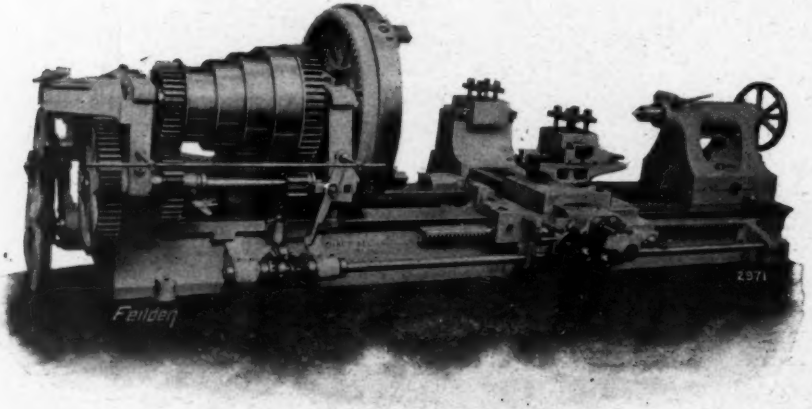


FIG. 7.—SCREW-CUTTING LATHE BY MESSRS. SHARP, STEWART AND CO.

the feed is put on by *swivelling the lathe head stock* while the tool stands still.

The spindle of the machine has a hole 8 ins. in diameter, bored in the front end a sufficient depth to receive the body of the buffer shells, and there are set-screws passed through it to grip the buffer at two places in its length, which give the spindle somewhat the appearance of a bell chuck. A bearing surrounding this large portion forms the front poppet, and this, in order to vary the radius, is made adjustable in the direction of the spindle's length upon the lower portion of the teeth upon its lower portion, so that a small pinion placed vertically may gear into it to impart the swivelling action to the headstock when required. The pinion receives its motion from a shaft that passes along inside the bedplate of the machine. The driving-gear for this shaft is situated at the opposite end of the machine to the belt pulleys. A tool-holder and transverse slide are mounted upon the front poppet, so that it shall move with the latter both longitudinally and when swivelling. With this the back part of the buffer plate may be turned while the

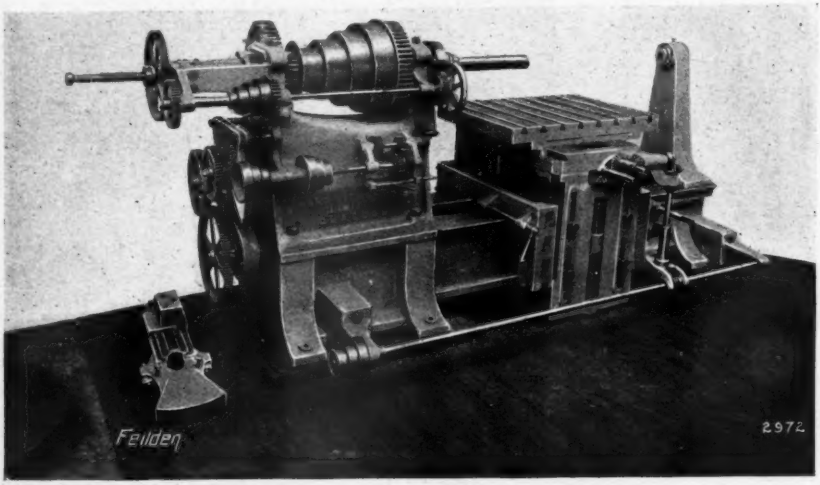


FIG. 8.—SCREW-CUTTING AND BORING MACHINE BY MESSRS. SHARP, STEWART AND CO.

swivelling headstock. The whole of the thrust is taken on this front poppet. The smaller portion of the spindle at its tail end is cut with a feather keyway, so that it may receive its drive from a rotating sleeve held in the back poppet. This sleeve in turn is rotated by two pairs of bevel wheels from a shaft below.

The headstock has a projection at its end, forming a trunnion about which it swivels, and this fits into a vertical bearing, and through its centre the spindle passes, carrying the bevel wheels. The front end of the swivelling headstock has spur-wheel

headstock swivels to machine the front. A locating bolt, similar to the kind of thing used in the turret lathe, is introduced to set the headstock in a central position when it is desired to do straight facing.

Turning from the Maclellan machine, a study in steam piping a short distance away catches the eye, and upon proceeding to investigate a little more closely, we find it is connected with the overhead gear of the Jones and Lamson lathes there exhibited.

We feel inclined to salute the pioneers

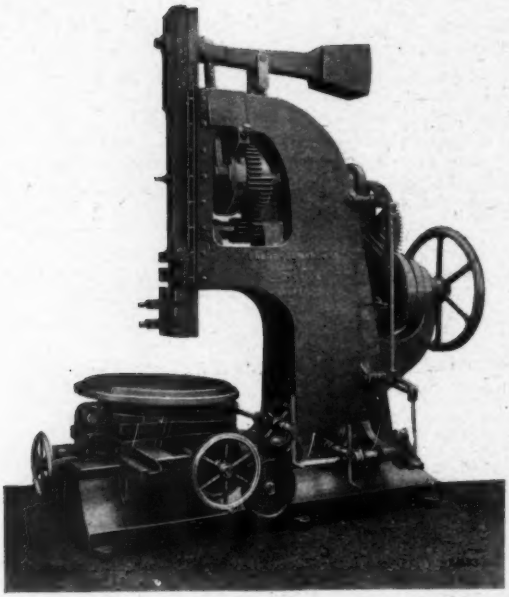


FIG. 9.—SLOTTING MACHINE BY MESSRS. SHARP, STEWART AND CO.

of the flat turret, for it is a good thing. Nothing much new to chronicle, for there are few points, so far as we can see, where the machine might be improved. In a machine of this kind, small changes are sure to be made from time to time as experience in the use of it shows the need of them. With this knowledge we look for trifles, and observe that a small self-centring scroll-chuck is now fitted to the tail end of the spindle, to keep the bar of stock in a central position. Upon inquiry, we find that the change has been made because it was found that when using a bar of metal smaller than the hole through the spindle, it was impossible to produce very accurate work by gripping with the collet chuck only, for the weight of the loose end of the bar tended to strain the chuck and throw the portion being turned slightly out of line. A trifle, certainly, but its addition improves the quality of the work produced.

After examining the details of the screwing die-head and other tools, we pass on to some of the near machine tool stands.

Messrs. Sharp, Stewart & Co. are showing several nice machines. The first that claims our attention is the new lathe patented by Mr. George Oldfield (Fig. 6). The machine is intended to turn all kinds of work from rough merchant bar, and is therefore a modified type of turret lathe. The head-stock, as is usual with all the best kinds of turret lathes, is fitted with friction back gear. The spindle is of large diameter, with parallel bearings of gun-metal.

As all makers of turret lathes of large size know, the design of a chuck for holding rough merchant bars presents some little difficulty, inasmuch as the variation in diameter is too great for an ordinary collet chuck to be successful.

Alfred Herbert solves this problem by introducing a machine-driven chuck with a differential screw, that tightens while the machine is running. Hartness designed a chuck of the collet type, with a modification of a toggle as the mechanical power for closing same. Ward follows the Hartness lead. Austin puts his favour on a simple toggle device, and Pittler prefers a system of wedges placed in series. Each of these devices mentioned may be actuated as the machine runs.

Oldfield has a collet chuck closed by the aid of worm gearing, which gives a considerable mechanical advantage. To work this chuck, the machine must be brought to rest, and a swinging arm at the back of the head-stock brought forward so that the worm which it carries may gear with the teeth cut in the exterior of the chuck-ring. No doubt with this arrangement a considerable range of motion may be had with the chuck, together with a very tight grip, which will enable it to securely seize a bar of rough metal with any ordinary variation in its size.

Two turrets there are, the one mounted upon a saddle with compound slides to carry five tools for external turning, the other, fitted to a carriage having somewhat the appearance of a loose head-stock, has four tool places to take drills and other tools for internal working.

Look a little more closely at the first turret, and it will be seen to have a somewhat unusual appearance for this detail. It is made to combine the function of a turret plus that of the tool holders, for it will take simple tools cut from the bar without forging, grinding being the only preparation necessary. The turret holders are themselves given the correct rake for the tool-cutting angle. Another point, is that the tools do not lie in radial lines from the centre of the turret, but their centre lines would be tangents to a circle several inches in diameter. The tool in action is thus considerably in advance of the turret centre, that is to say, nearer the fast head-stock. This enables the tool to continue its cutting right up to the chuck, so diminishing the amount of overhang. The saddle may be traversed from the back shaft, to which six speeds may be given, the change being quickly obtained by handle motions.

On the Hartness and some other capstan lathes, when a screw is to be cut, the die gives its own lead from the position of the screw already threaded, after the turret has been put forward for the start by hand. On this machine, although a screwing head is used, there is a leading screw with change wheels as in an ordinary screw-cutting lathe. For the cutting of accurate screws, the lead-screw is used in conjunction with the die-head, or if required it can, of course, be used for screw cutting as in an ordinary lathe.

For taper turning, the upper slide upon which the turret fits may swivel to the required angle. Stops are fitted, both for the longitudinal and cross feeds.

The second turret is of square shape

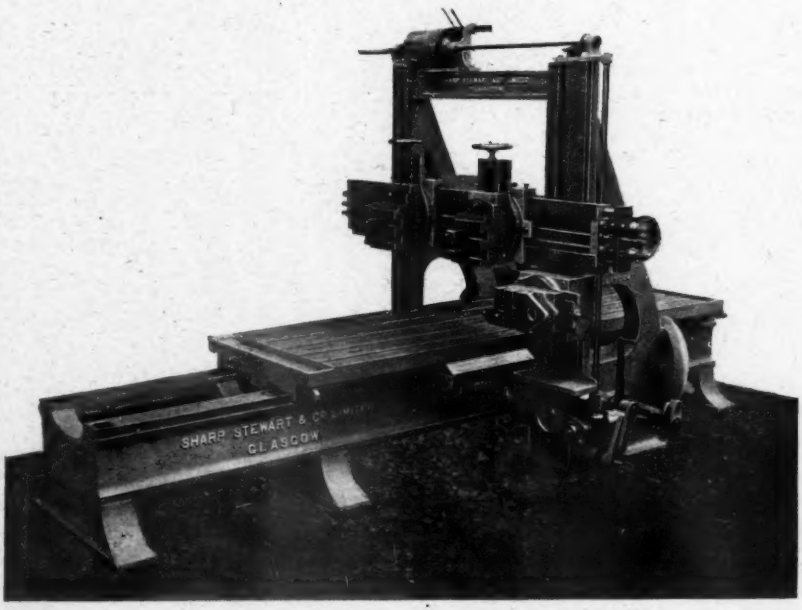


FIG. 10.—PLANING MACHINE BY MESSRS. SHARP, STEWART AND CO.

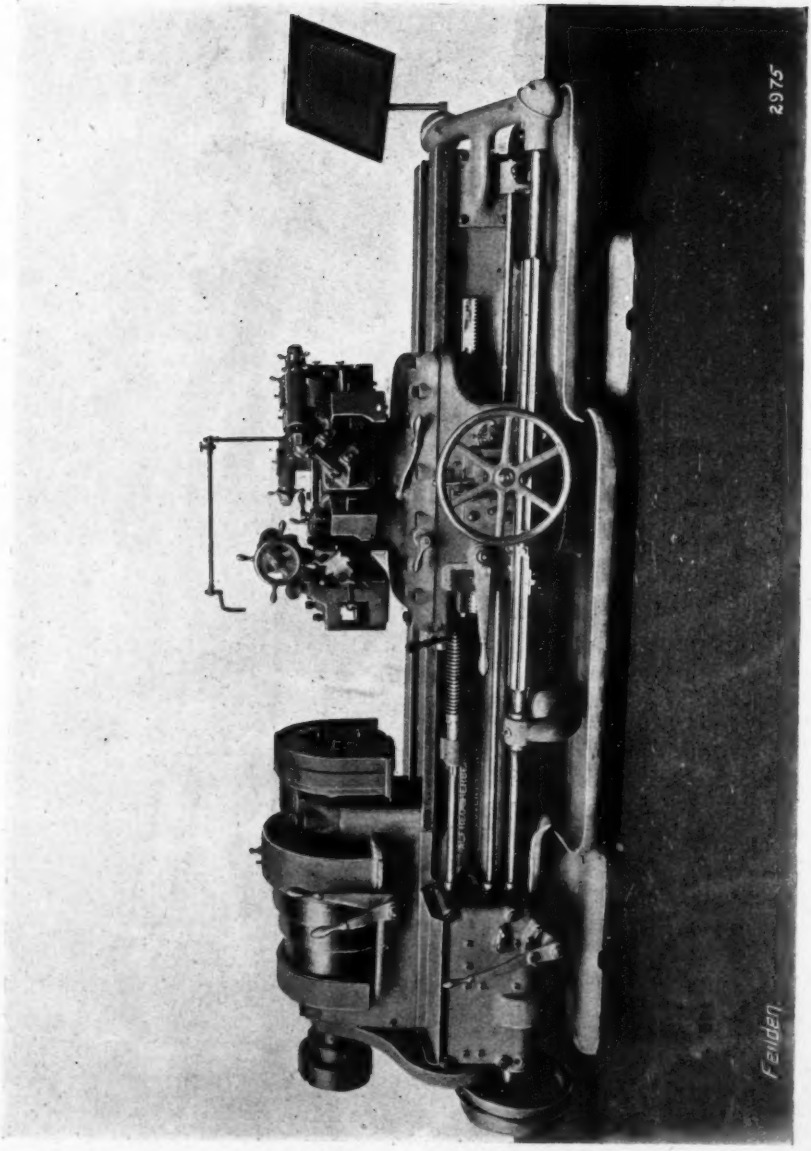


FIG. 11.—TURRET LATHE BY MESSRS. ALFRED HERBERT.

with four tool places, the centre lines of the tools in this case also being tangents to a circle struck around the turret's centre. The centre line of the loose head-stock is therefore set back from the centre line of the work an amount equal to the radius of the circle. This second turret, in one of its tool places, usually carries a back-centre, so that for long work it may act precisely as an ordinary loose head-stock; but, as it also has to carry drills and such-like tools in the other places, special facilities are introduced for traversing the loose head-stock along the lathe bed. The machine, it will thus be seen, has several novel points which will, no doubt, commend it to many engineers. It may perhaps be noted that the change wheels are loose, and require handling in the usual way.

Perched on the top, like Chanticleer on a dung-hill, is the ever-present drip-can.

Were I a cutting tool, my plaint should be—"Preserve me from a drip-can!"

Why tickle my cutting-edge with a spot of soapy water, which makes me feel the heat like sweat upon the brow?

My cry should rather be—"Put me under the pump."

Why will not the builders of machine tools fit pumps and suds-trays to all of their machines, and give the cutting-tools a chance by copious lubrication? It is a matter of common knowledge that a machine so fitted has its possible output increased about thirty per cent.

In heavy tools, Messrs. Sharp, Stewart & Co. have some fine things on view. There is a large lathe of 27 ins. centre and 18 ft. length of bed, built for rapidly turning the heaviest kinds of steel forgings, such as propeller shafts, gun tubes, etc. (Fig. 7.) The bed-plate is constructed so that additional lengths can be fitted, that its length may be increased to 30 ft. or 40 ft. if required. It is a thoroughly substantial treble-geared machine with a face-plate chuck and duplex rests, one at back and the other in the front, both upon the same saddle.

There is comparatively little to be seen at the exhibition in the way of boring machines, but this firm are showing one with a horizontal spindle that is quite an improvement in this type of thing, and it may be spoken of as a modernised horizontal boring machine, although the makers are content to speak of it as improved. (See Fig. 8.) It fulfils three several functions; for, in addition to boring, it is intended for drilling and internal screw cutting. In general appearance the framework of the machine somewhat resembles that of a high centre lathe, with an adjustable table fitted in the stead of a slide rest.

The table is provided with both transverse and vertical slides, the latter fitting in ways at the back and front of what may be spoken of as a saddle. Thus, the table may be adjusted both vertically, longitudinally, and transversely. The two latter may be power-driven, for feeding. The saddle may be given its longitudinal traverse from a lead-screw that passes in the interior of the lathe bed, and as the screw is provided with the usual change wheels, it may be used for screw cutting. The mechanism for feeding the boring bar is sufficiently clear in the illustration to require no additional explanation.

There are one or two points in a large slotting machine (Fig. 9), exhibited by Messrs. Sharp, Stewart & Co., which are worth noting. The table, to which the usual motions can be given, is pivoted about a hinge at the back, so that with the help of an elevating screw at the front, the table may be tilted for the purpose of cutting such things as key-ways in propeller-bosses, etc. This tilting of the table, which may be measured by a scale at the front, does not in any way interfere with the other motions.

The next point is, the method of relieving the machine bearing of excessive pressure when the tool is cutting, by fitting an adjustable pad over the top of the crank disc. To get a quick return of the tool, elliptical gear is used, in combination with an ordinary spur wheel, so that a steady cutting speed is obtained in addition to the quick return.

The last machine to which we have to refer, as exhibited by Messrs. Sharp, Stewart & Co., is one to plane 4 ft. by 4 ft. by 10 ft. It is built to have a cutting

speed of 25 ft. per minute, with a return of 125 ft. per minute (Fig. 10).

The driving gear adopted is that which was introduced by Dr. Sellers, and consists of a rack beneath the table, gearing with an inclined worm. The spindle upon which the worm is fitted, terminates at one side of the machine to the rear of the uprights, with a large bevel wheel. A second small bevel wheel of raw hide, with machine-cut teeth, engaging this, is mounted upon a shaft running across the machine bed, with the driving pulleys, etc., on the far side.

Another feature of the machine is that it is provided with Robinson & Oldfield's patent feed-gear, which makes it possible to give a much broader feed than can be obtained with the old arrangement. Beyond these points, the machine has much the appearance of the usual planing machines, with the difference that it is fitted with flat slides, instead of the usual V's, but it is quite an open point as to the value of this difference.

It is with a feeling of satisfaction that we saunter on to Messrs. Alfred Herbert's stand, for, from previous experience, we are assured there will be plenty to claim attention, some things old and some things new.

Great turret lathes and automatic machines; they revel in them here.

Three-and-a-half inch steel bars are a mere nothing—slip it into a turret lathe and turn it into bolts.

Their No. 4 turret lathe is a machine worthy of the name, and made in England.

One only gets half an idea of this machine from an illustration (see Fig. 11), for its proportions can be but imperfectly realised. As already inferred, the machine is capable of taking a three-and-a-half inch bar through the spindle, and it can turn up to a length of 48 ins.; all other parts of the machine are in proportion.

The head-stock of 12-in. centre is fitted with double friction back-gear, that enables the operator to get three speeds without stopping the machine or moving a belt. The cone has three steps, thus, by combining the speeds therefrom with

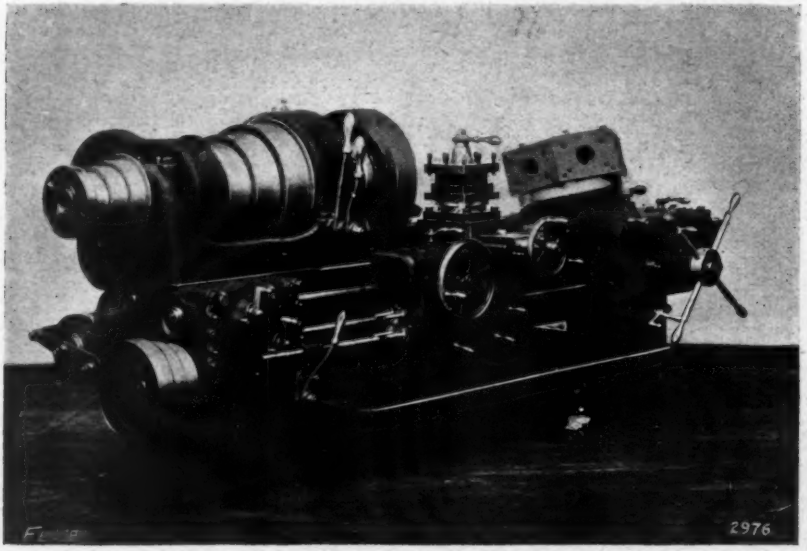


FIG. 12.—TURRET LATHE BY MESSRS. ALFRED HERBERT.

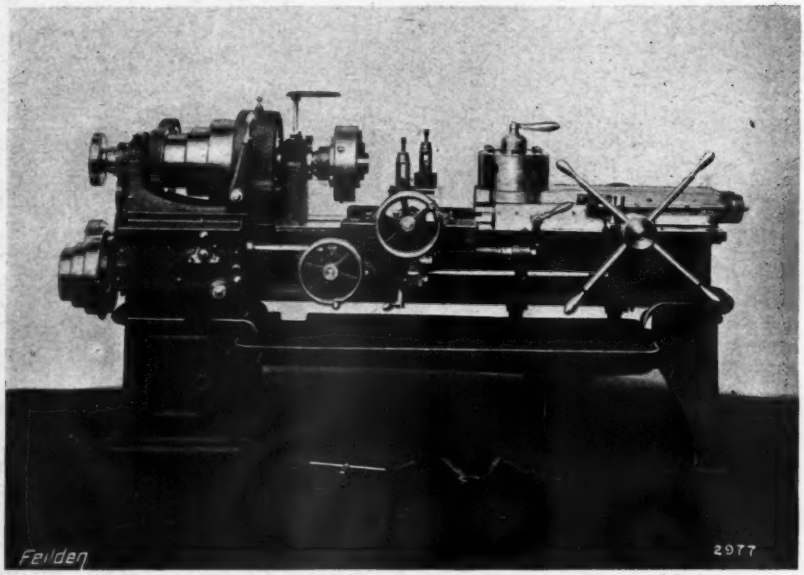


FIG. 13.—TURRET LATHE BY MESSRS. ALFRED HERBERT.

those obtained by the back gearing and the two-speed counter-shaft, a total of 18 different speeds of revolution is obtainable at the spindle. An 18-in. three-jaw chuck, with cover, is fitted to the front end of the spindle, and another, 12 ins. in diameter, is attached to the back end.

The turret is hexagonal in form, hollow in its interior, and there are massive tool-holders to bolt upon the flats. It is mounted upon a long substantial saddle that slides directly upon the bed. It is provided with six self-selecting feed-stops, which throw out the automatic traverse where required. These will be seen to be upon a hexagonal bar at the front of the machine. They are caused to rotate in unison with the turret by bevel wheels and a cross spindle at the end of the machine, and a shaft that runs along the lathe bed beneath the turret with a connection thereto.

When the stops are engaged, a small trigger is withdrawn which allows a tumbler carrying the feed connection to drop out of action. One important point is that in addition to the feed-traverse a second power-traverse, much quicker in its operation, can be brought into use when required, to quickly travel the turret either forwards or backwards. This is to obtain quick movements when the tools are not cutting and it is required to change the position of the turret.

With a heavy machine of this type it would be impossible to cut screws accurately from a die head, therefore an automatic traverse, obtainable from a leader screw, is essential.

There are thus three different methods of traversing the saddle—the quick power-traverse, the feed-traverse, and the screwing-traverse. If it were possible for any two of these to be thrown into use at one time a breakage would certainly occur. An interlocking arrangement making it impossible for more than one feed to be in use at a time is, therefore, embodied in the mechanism.

The turret with its tools is very heavy,

and to rotate it by hand would normally require considerable effort. A device is accordingly introduced which raises a ball step-bearing beneath the turret, raising it from its seat when the locating bolt is withdrawn. This reduces the friction and makes it possible to turn the turret with reasonable freedom.

Several separate leader screws are provided with the machine, and with these, in conjunction with a few change wheels, any screw thread likely to be wanted on a machine of this size can be cut, and there will be no danger of making a false start when using the die head or of crossing the threads with the chaser.

A large pump is fitted to the machine to circulate the lubricating oil, and an oil-supply may, when required, be arranged to pass through the turret tools for drilling and boring.

To illustrate the use of the turret lathe for machining castings, Messrs. Alfred Herbert are exhibiting their so-called No. 6 inclined turret lathe (see Fig. 12). This machine has two saddles, each carrying a turret. One of these may be considered as taking the place of a cutting-off slide. The turret upon it is square, and the tools it carries are intended to machine the exterior of the casting. The other turret is six-sided, with a hollow interior and inclined toward the back of the machine. It is intended to carry, by the aid of suitable holders, such tools as drills, reamers, etc., for boring out the interior of the casting or turning the face.

Each of these two turrets may be given an independent power-traverse, and they each have separate self-sorting stops, to automatically throw it out when required.

There are various other conveniences, such as friction back gear, handle change-feed, etc., as is desirable on a machine of this kind.

At the Exhibition, the machine is at work upon different-sized gear blanks for the spur-wheels embodied in the various machines made by the firm.

Another machine, set up to work upon castings, is fitted with tools to machine the body of a 2-in. brass globe stop-valve (see Fig. 13).

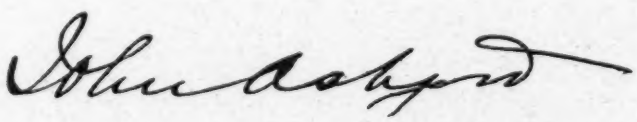
The visitor at the Exhibition would do well to examine the tools upon this and other machines on this stand, as they form excellent examples of the tool maker's art.

Perhaps the two most interesting features about the machine itself are, firstly, the self-sorting stops for the turret, which have a slight resemblance in miniature to that upon the large machine described, and, secondly, the arrangements in connection with the chasing saddle.

For the purpose of chasing, a number of leader screws are provided, and there is a combined quick withdraw and nut release.

The self-sorting stops may be observed to be attached to the turret slide behind the capstan handles.

(To be continued.)



MACHINERY APPLIANCES AND PROCESSES

"Every part and side of our life, from the cradle to the grave, has been touched and tended by the inventor and manufacturer. His works are as numberless as the sands of the sea, but the onward rush of Science and the Arts opens up new fields of discovery and enterprise as each day dawns. Let us choose here and there among thousands, and in choosing take the best as far as in us lies."

THE NEW REDHEUGH BRIDGE, NEWCASTLE-ON-TYNE.

In spite of its importance, the city of Newcastle shows, and has shown within the memory of man, a strange lack of initiative with regard to municipal enterprise. Most of the architectural, engineering, and other improvements that have been effected in the past, or are at present in progress, are due to private individuals or to commercial companies. These remarks apply with especial force to means of communication between Newcastle and the adjacent town of Gateshead, for Stephenson's high-level bridge remained the only convenient route for traffic until the completion, in 1871, of the Redheugh Bridge by the company of the same name. The latter structure, erected from the designs of Sir Thomas Bouch, served a useful purpose for many years, but at last it became evident that the great increase of traffic and the safety of the public demanded its removal and the substitution of a new bridge. For the purpose of obtaining powers to carry out these necessary works the Redheugh Bridge Act was brought before Parliament, and in 1896 the company became duly authorised to take down the old bridge and approaches and to erect a new bridge and approaches in substitution thereof.

Before proceeding to give a general description of the new structure, it is necessary that a brief reference should be made to the old bridge, and to the exceptional conditions under which the work of replacement had to be conducted. By reference to Fig. 1 it will be observed that the old Redheugh Bridge was of a compound type, which may be termed "suspended lattice girder," having three river piers and four spans, approached by a masonry viaduct from each side of the river. The approximate dimensions of the bridge were as follows: Length of Newcastle shore span, 168 ft.; first mid-river span, 252 ft.; second mid-river span, 252 ft.; Gateshead shore span, 167 ft.; total length between the masonry piers, 839 ft. The total length of the approaches was 348 ft., the Newcastle approach being 216 ft. long, and the Gateshead approach 132 ft. long. Thus the total length of the bridge and approaches was about 1,187 ft. From the high-water level of ordinary spring tides to the under side of the bridge the height was 86 ft. 7½ ins. The height of the approach footpaths above the same level varied from about 75 ft. on the Newcastle side to a little more than 99 ft. on the Gateshead side of the river. The total width of the bridge proper was approximately 41 ft., including a roadway 20 ft. wide and two footpaths each 7 ft. wide. Incorporated with the main longitudinal girders were gas and water mains, the former constituting the upper booms and the latter lying in the trough-shaped lower booms, these conduits belonging to the Newcastle and Gateshead Gas and Water Companies respectively; and it may be remarked incidentally that both these corporations are considerable shareholders in the Redheugh Bridge Company. As it was decided that the new bridge should be erected on the same axis as the old one, the problem for the engineers was to evolve a design that would entail the least possible interruption to traffic both on the bridge itself and on the river beneath it. What was the nature of that design, and how it was realised, we shall presently see. For the moment it may be noted that very stringent conditions applied to the contractors in respect of interference with traffic. It was stipulated that the roadway should be kept open for the passage of vehicles until it became absolutely necessary to close it, and no interference with traffic could take place without the consent in writing of the

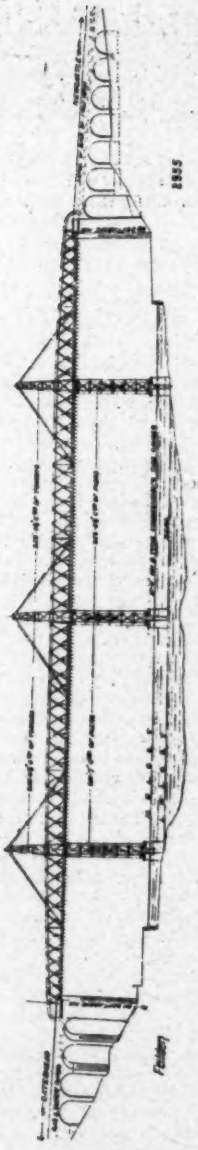


FIG. 1.—OLD REDHEUGH BRIDGE (LOOKING UP-RIVER).

engineers, or without three weeks' previous notice to the general public. The contractors were also by terms of the contract to maintain at all times a good and sufficient pathway for foot passengers between Newcastle and Gateshead. That the foregoing stipulations were successfully complied with is primarily due to the forethought of the engineers, but credit must also be awarded to the contractors for careful and skilful execution of the designs. The work to be done under the contract may thus be generally described :—

(1) To remove the main spans and river piers of the old bridge down to low water of ordinary spring tides. (2) To remove the old approach viaducts, down to the level of the springing of the arches, between the extreme abutments and the large stone main girder piers on each side of the river. (3) To remove the old gas and water mains. (4) To erect an entirely new main bridge, complete with new cylinder foundations and river piers, between the large stone piers on each side of the river. (5) To erect entirely new steel girder approach spans, carried on new pier heads and abutment walls built up on the old stone piers and abutments. (6) To provide and set in place new steel gas and water mains, and to execute all necessary diversions of gas and water from the old to the new mains. In addition to the conditions previously mentioned, the contractors were to accept responsibility for the actual nature of the strata to be excavated; the whole of the setting out of lines and levels was, however, done by the resident engineer. They were, of course, responsible for the whole of the materials and work specified, for all plant, and for sundry temporary works specified in general terms by the engineers, and they were also required to maintain the new structure for a period of twelve months after completion.

We may now conveniently proceed to examine the main characteristics of the new bridge, of which a longitudinal elevation and plan are given in Fig. 2. By this illustration it is shown that the new bridge has three river piers whose longitudinal spacing is coincident with that of the old piers, the four spans being of the "Petit" truss type, and supported by knuckle plates and pins. The approaches on either side of the river include steel superstructures supported on masonry piers and abutments. As may be anticipated, the total length of the new structure is the same as that of the old bridge, the two side spans measure 168 ft. between the centres of the bearings, and the two mid-river spans 248 ft. between

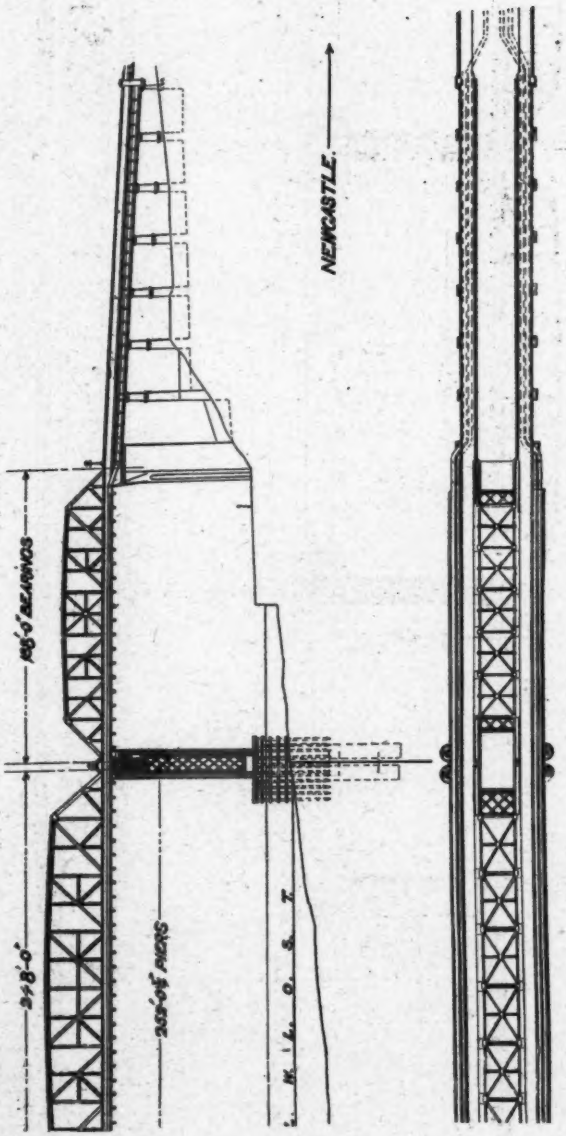


FIG. 8.—NEW REDHEUGH BRIDGE: PART PLAN AND ELEVATION.

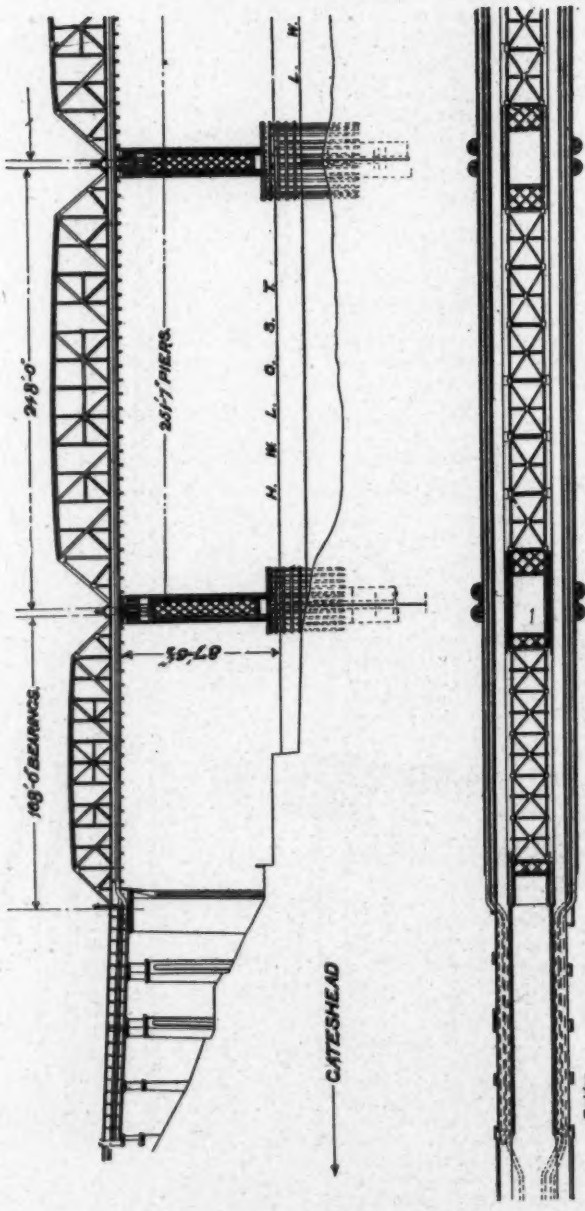
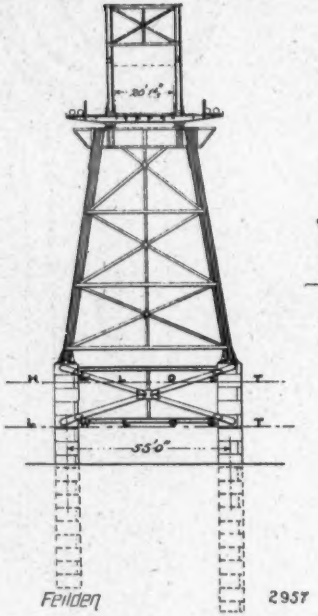


FIG. 2 (CONTINUED).—NEW REDHEUGH BRIDGE: PART PLAN AND ELEVATION.



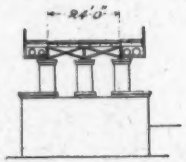


FIG. 3A.—CROSS SECTION THROUGH NEWCASTLE APPROACH.

FIG. 3. —NEW REDHEUGH BRIDGE. CROSS SECTION THROUGH CENTRE SPAN.

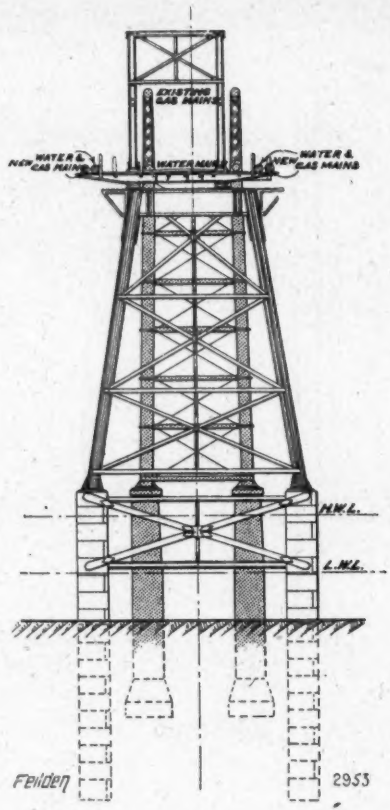


FIG. 4.—REDHEUGH BRIDGE: CROSS SECTION SHOWING RELATIVE POSITION OF OLD AND NEW BRIDGES.

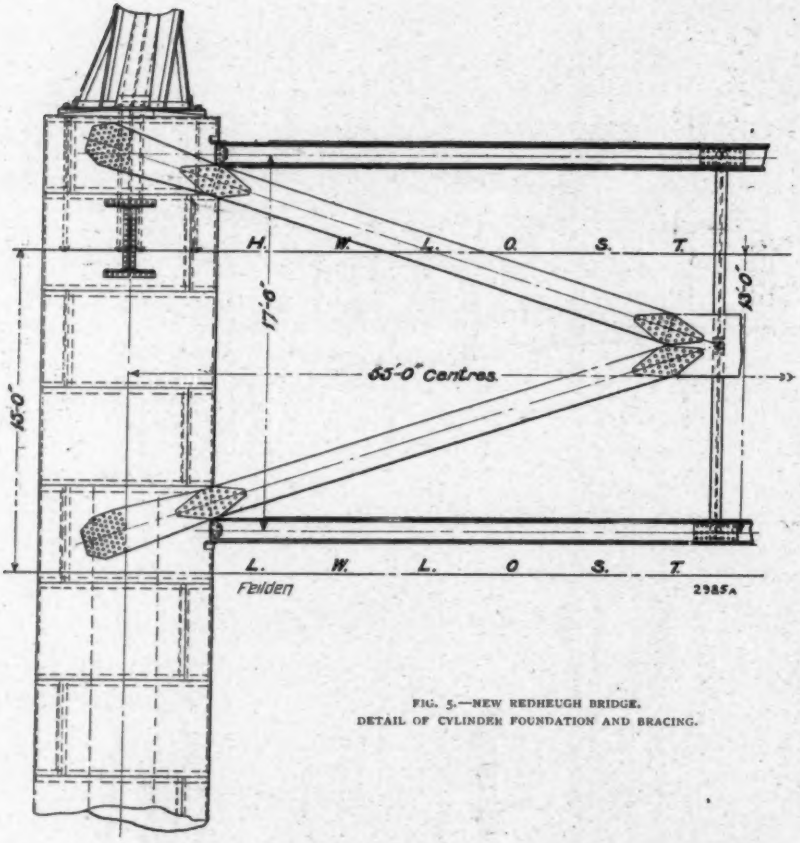


FIG. 5.—NEW REDHEUGH BRIDGE.
DETAIL OF CYLINDER FOUNDATION AND BRACING.

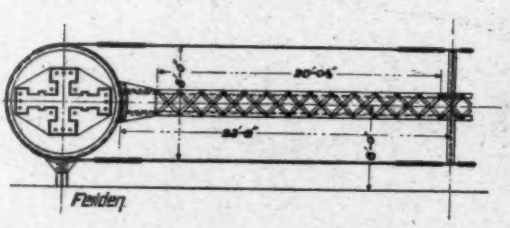


FIG. 6.—NEW REDHEUGH BRIDGE.
PLAN OF CYLINDER FOUNDATION AND BRACING.

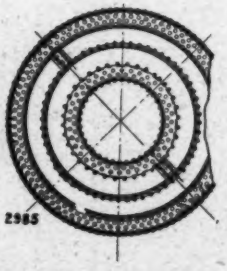


FIG. 6A.—SECTION THROUGH
CYLINDER FOUNDATION.

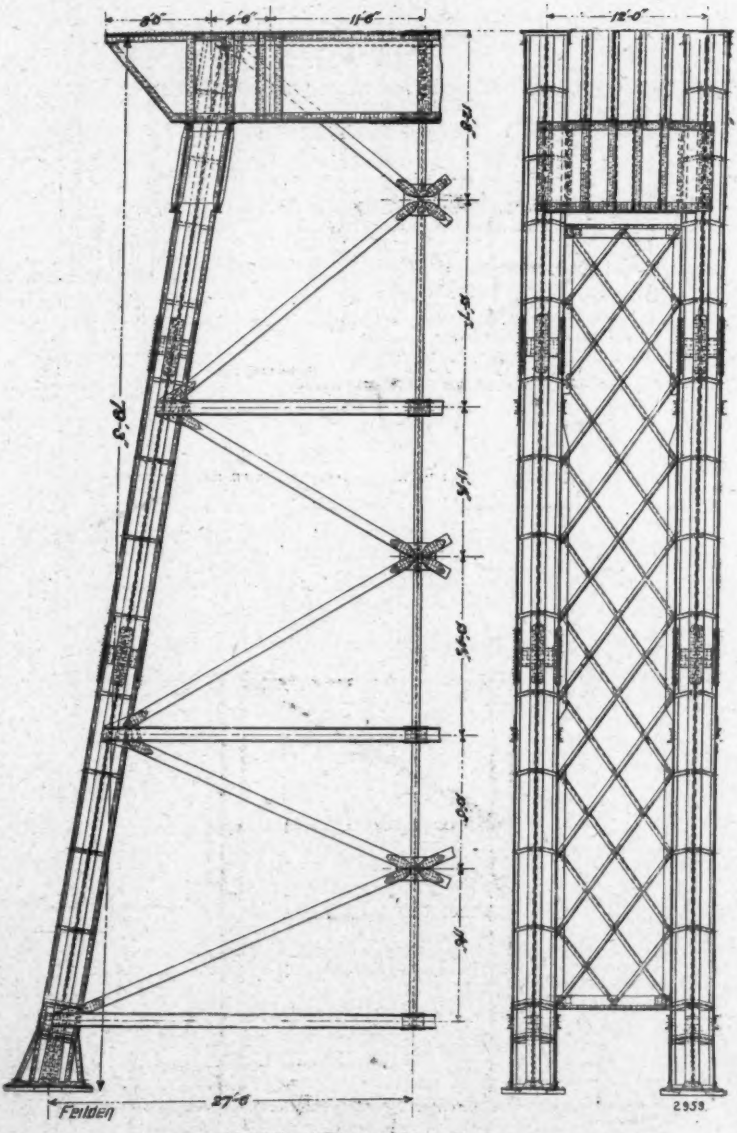


FIG. 7. FIG. 8.

NEW REDHEUGH BRIDGE: END HALF ELEVATION AND SIDE ELEVATION OF CENTRAL RIVER PIER.

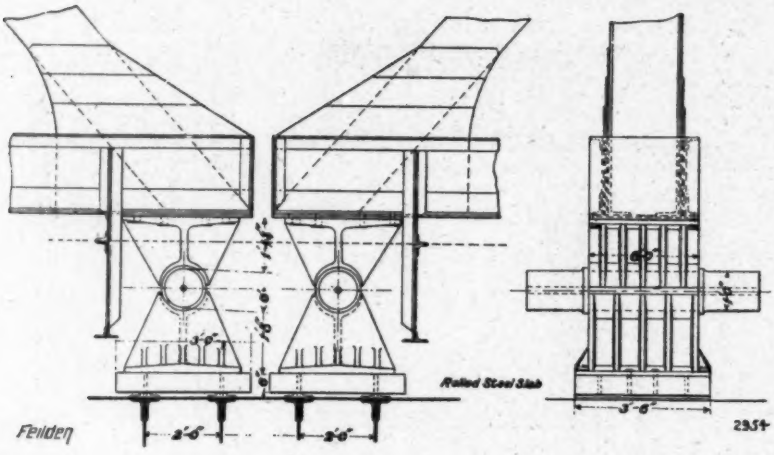


FIG. 10.—NEW REDHEUGH BRIDGE: DETAILS OF MAIN GIRDER BEARINGS OF CENTRE PIER.

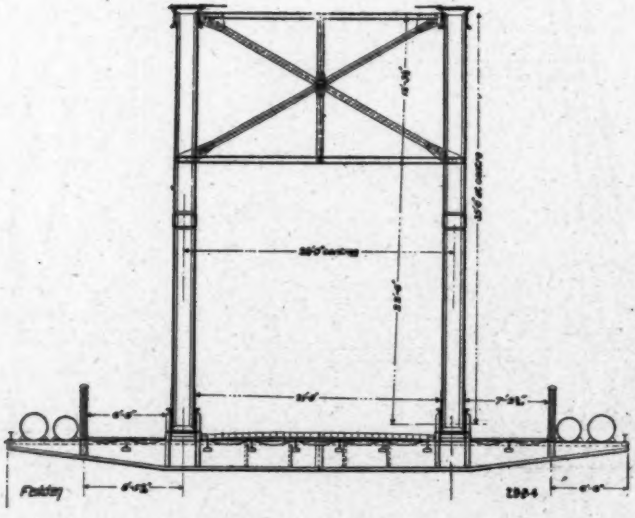


FIG. 12.—NEW REDHEUGH BRIDGE: CROSS SECTION AT CENTRE OF 248 FT. GIRDER.

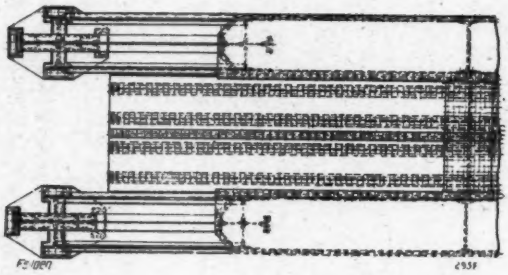


FIG. 9.—NEW REDHEUGH BRIDGE: HALF PLAN OF CENTRAL RIVER PIER.

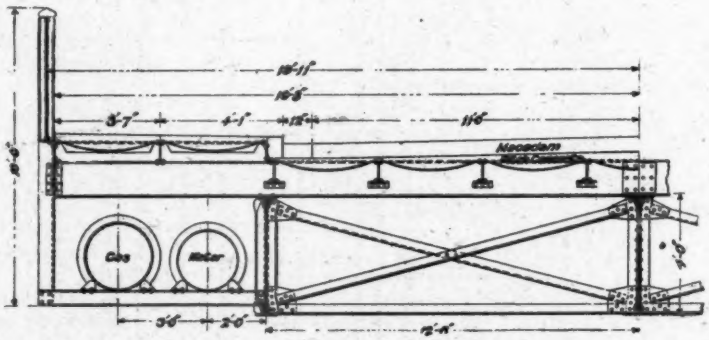


FIG. 13.

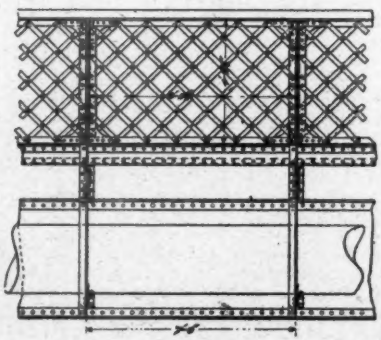


FIG. 14.

DETAILS OF STEELWORK IN APPROACHES.

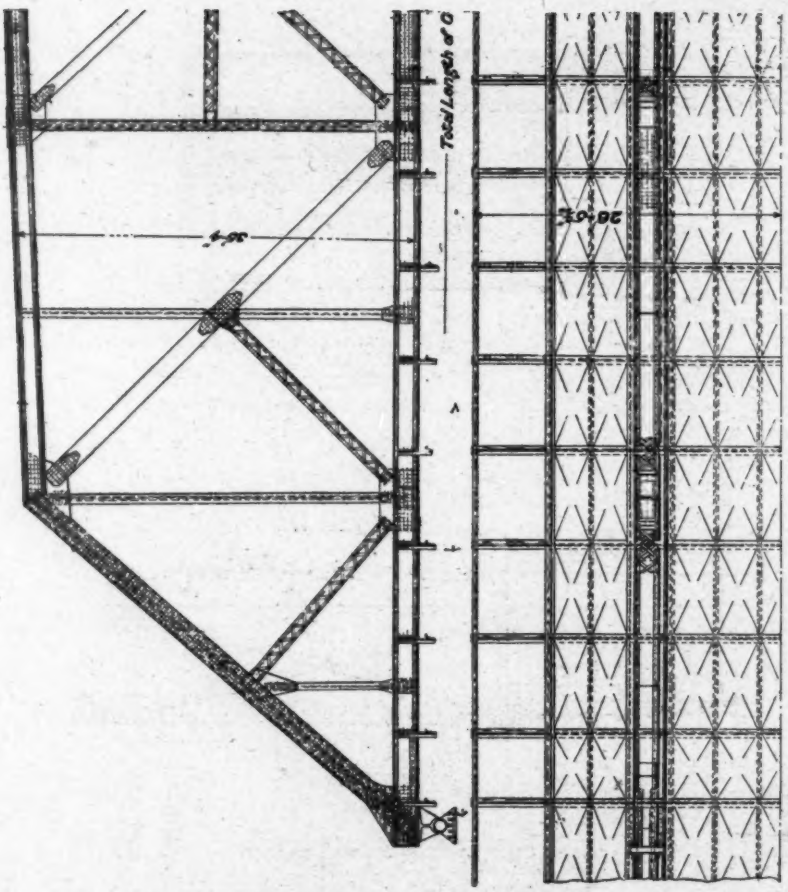


FIG. 11.—NEW REDHEUGH BRIDGE: DETAILS OF 248 FT. GIRDER.

similar centres, the measurements between pier centres being, of course, slightly greater. The total width of the bridge platform is about 53 ft., including a roadway 20 ft. 1¾ in. wide, two footpaths each 7 ft. wide, and a space outside the latter on each side of the bridge to carry gas and water pipes, as shown in Fig. 3. In Fig. 3A a cross-section of the Newcastle approach is reproduced, where it will be seen that the width of the roadway is increased to 24 ft., the extra space being made available by the absence of steel work above the road level. It will also be noticed that in the approaches the gas and water pipes are carried below the footpaths on either side of the roadway.

Having before us the outlines of the old and new bridges, we can see how it became possible to accomplish the task of building one structure in the space occupied by the other before the latter had been dismantled or removed. To be precise, this is not what actually took place, for the new bridge was built partly around, partly outside, partly inside, and partly above the old one, whilst the approaches were changed by a process of sectional substitution, which will be particularised later. Fig. 4 is a section showing the relative position of both bridges during the erection of the new structure. Here we see the river piers and their foundations outside the old supports, and the new super-

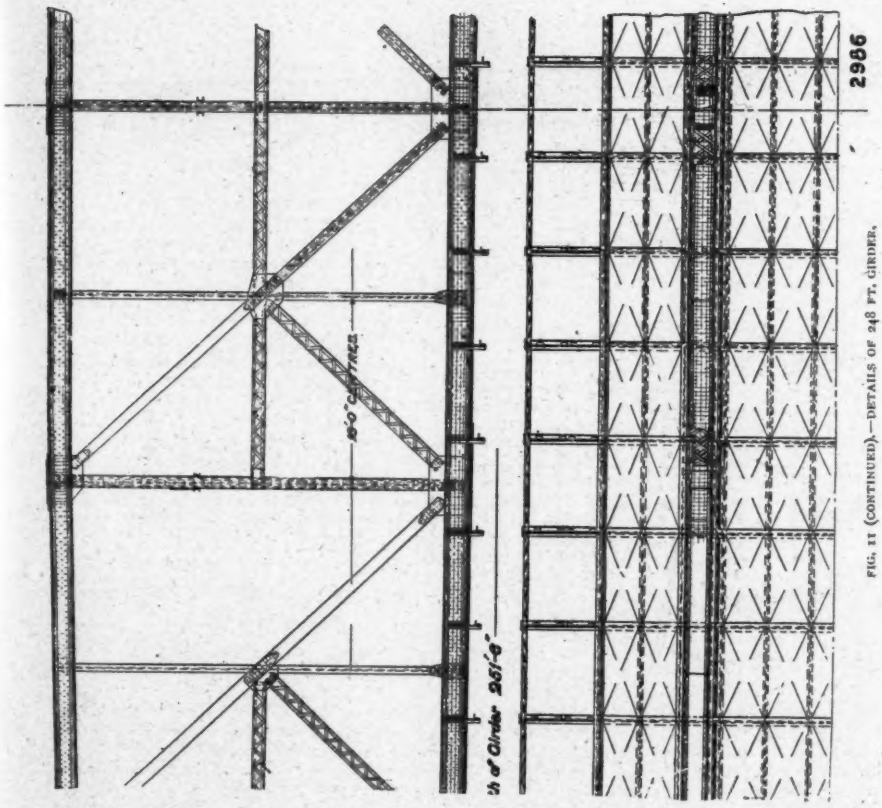


FIG. 11 (CONTINUED).—DETAILS OF 248 FT. GIRDER.

structure in the place where it was assembled to avoid interference with the same portion of the then existing bridge. When the proper time came the old bridge was finally cleared away, and the new spans were removed to the central position indicated by Fig. 3.

In approaching the consideration of structural details, we will first take those connected with the foundations. For their own information and for the guidance of the contractors, the engineers ascertained by borings, the nature of the strata lying beneath the sites of the pier foundations, and the results so obtained were shown in detail on the drawing, of which Fig. 2 is a reduced reproduction. The foundations were of the cylinder type, the tops of the cylinders projecting 6 ft. above high-water level, whilst the bottom sections were sunk to a depth ranging from 50 ft. and upwards below the river bed, the exact depth being determined in each case by the engineers. Owing to the proximity of the foundations of the old bridge, the sinking of the new cylinders was performed by the plenum-pneumatic process, in which the removal of material permits the cylinders to sink gradually, whilst the adjacent earth is kept from flowing in by the maintenance of an interior pneumatic pressure slightly in excess of the exterior hydrostatic pressure. One important point in connection with this method of work is that the air pressure should always be proportionate to the depth below water, and the engineers in the present case wisely stipulated that pressure should never be lowered with the object of facilitating sinking. Further, they placed a strict limit on the practice of undercutting the soil below the cutting edges of the cylinders, specifying, as a general rule, that sinking should be carried out by

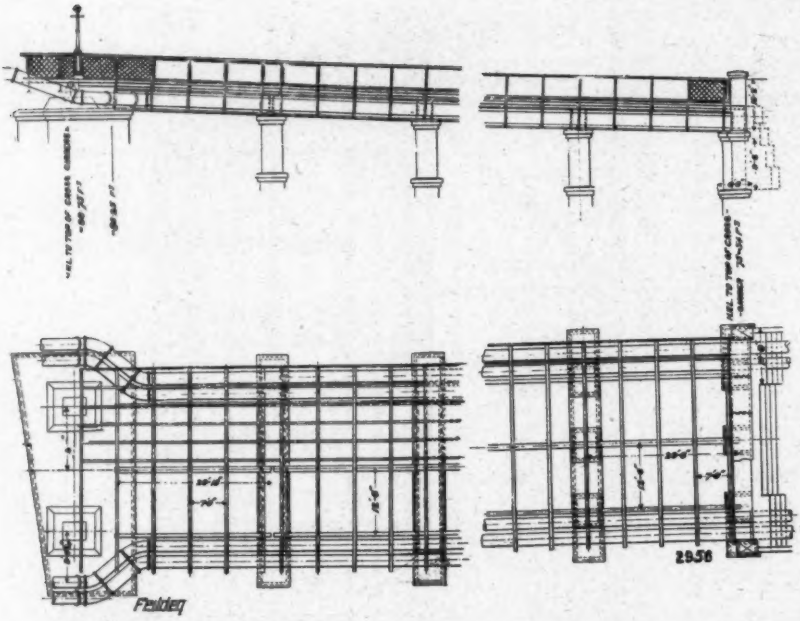


FIG. 15.—NEW REDHEUGH BRIDGE: PART ELEVATION AND PLAN OF NEWCASTLE APPROACH.

the excess of weight of cylinder, concrete, and ballast over the frictional resistances and air pressure. The outer tube of each cylinder was formed of rings of mild steel plate, 8 ft. diameter by 4 ft. 6 ins. long by $\frac{13}{32}$ in. thick in the first twelve rings from the top, and $\frac{5}{16}$ in. thick in the remaining rings. A making-up length was provided for each cylinder, finished at the top end with an angle-bar ring of $3\frac{1}{2}$ ins. by 3 ins. by $\frac{1}{2}$ in. section, so as to bring the cylinder head to its proper level. The separate rings were joined together by circumferential internal covers 6 ins. wide, under which the vertical joint covers, 4 ins. wide, were tucked after being thinned down, and spread out. The inner tube of each cylinder is made in two lengths of 22 ft. 6 ins. by 3 ft. diameter, and below the bottom length is the working chamber, 9 ft. in height by 4 ft. diameter at the upper end, 6 ft. 9 ins. diameter at a distance of 7 ins. from the bottom; the remainder of the chamber is bounded by an angle ring, of 7 ins. by 7 ins. by $\frac{1}{2}$-in. section, riveted through the outer cylinder caulking and an external circumferential plate 7 ins. wide by $\frac{7}{16}$ in. thick. Both the inner tube and the working chamber are formed of mild steel plate, $\frac{7}{16}$ in. thick, and they are suitably jointed and held in position by angle rings and stays. All joints in the cylinders were caulked water- and air-tight. Air-compressing plant, air-locks, and fittings were of course provided in every case, the latter including safety cocks, both inside the working chamber and outside the air-lock, for preventing the escape of compressed air in case of accident to the supply pipe, or breakdown of the machinery. Proper means of access to and egress from the air-locks and working chambers, and satisfactory devices for signalling from the interior of the air-locks and cylinders to the outside were also furnished.

With the object of providing an additional safeguard against any inrush of the surrounding earth, only one change of position of air-lock was permitted during the sinking of each cylinder, this change taking place before the cutting edge of the cylinder had been sunk to a depth of 28 ft. below low-water level.

In order to make absolutely sure of the safety of the old bridge during the sinking

of the cylinders the contractors, with the approval of the engineers, erected a timber trestle at each pier successively, which extended from the tops of the existing timber protection jetties to the tops of the old pier columns, to which it was securely attached by temporary steel collars. In the bottom of the working chamber of the cylinder an additional precaution was taken in the use of a timber grillage in order to further check an inrush of soil should such occur at the lower stages of sinking.

When once commenced, the operation of sinking was kept continuously going until the final depth was attained. The concrete was filled in around the working chamber and inner tube simultaneously with the sinking. The working chambers in every case were completely filled with concrete allowed to set under pressure, the first layers being lowered down to the foundations, and the last of the filling material being sufficiently fluid to flow freely. It was then worked thoroughly under the roof of the chamber, and carried up to give a head of about 2 ft. above the roof of the chamber. With the exception of the upper plug, the concrete in the cylinders was of the following proportions:—Cement, 1 part; sand, 2 parts; gravel (1-in. sieve), 2½ parts; and gravel (2-in. sieve), 2½ parts, or an equal proportion of broken stone. The final plug of concrete at the head of each cylinder was put in from low-water level after the attachment of the connections for the bracing mentioned below. The following proportions were adopted for the final plug of concrete:—Cement, 1 part; sand, 1½ parts; gravel (1-in. sieve), 2 parts; and gravel (2-in. sieve), 2 parts; or broken stone, 2 parts. Exceptional care was exercised with regard to the purity of the cement, the nature and condition of the aggregates, and the method of mixing and depositing the concrete in site. In connection with the last mentioned operation, men were always kept employed in shovelling and treading each mixing of concrete as it was deposited, being provided with water-tight boots of indiarubber. The lowest layers throughout the foundations, and the first layers deposited upon any concrete that had set, were invariably lowered down;

FIG. 16.—OLD REDHEUGH BRIDGE, MAY 17, 1892.

FIG. 17.—NEW REDHEUGH BRIDGE, JAN. 29, 1901, SHOWING PORTIONS OF OLD STRUCTURE.

any concrete deposited upon a soft layer of the same material was not permitted to be cast from a greater height than 8 ft., and the upper surface of all concrete that had set was thoroughly roughened, brushed clean, and treated with a layer of cement mortar, spread over immediately before the imposition of a new layer of concrete. Incidental mention was made above of the cylinder bracing, but, in order to make the matter clear, it should be explained that two pairs of cylinders form the foundation for each river pier, the individual cylinders of each pair being 12 ft. apart, centre to centre, and each pair being 55 ft. apart, centre to centre. The cross-bracing consists of plate girders 4 ft. long by 3 ft. deep by $8\frac{5}{16}$ ins. wide, secured to the cylinders by suitable connections. The bracing between the pairs of cylinders is partly illustrated in Figs. 5 and 6. The upper and lower struts, each 47 ft. long and 17 ft. 6 ins. apart from centre to centre, are 1 ft. deep by 1 ft. 10 ins. wide, and suitably connected at each end, are built up of two 12-in. by $3\frac{1}{2}$-in. channels, with horizontal bracing at top and bottom, as seen in Fig. 6. At the centre, line the two struts are joined by cross-bracing, shown in plan by Fig. 6 and in elevation by Fig. 5. The outer members of the cross-bracing are tee-bars, 6 ins. by 3 ins., riveted to the inner faces of the strut channels, and bent outwards to form a lozenge-shaped figure, 17 ft. 6 ins. high by 8 ft. wide, divided into two triangles by a pair of 3-in. by $2\frac{1}{2}$-in. angle bars, and each of these parts is sub-divided into four approximately equal triangles by bracing of similar section. At the extremities of the minor axis of the cross-bracing are attached the diagonal ties shown in Figs. 5 and 6. These ties are of 17-in. by 1-in. plate, secured at one end by covers to gusset-plates riveted to the centre of the cross-bracing, and at the other end by covers riveted to gusset-plates attached to the cylinder shells. Fig. 6*a* is a sectional plan through the lower part of a cylinder above the working chamber. Before passing away from the cylinders we must mention that the foundation bolts of the bed-

plates of the river pier columns were set in position in the concrete filling of the cylinders, having iron pipes around them for the full length plugged at their lower ends with oakum. The bolts were thus free to move horizontally within a limited radius for the reception of the cast-iron bed-plates. Sixteen bolts, set in pairs, 6 ft. 5¼ ins. long by 1½ in. diameter, were used for each pier column, arranged as shown in Fig. 6, and they were provided with foundation plates 1 ft. 6 ins. by 6 ins. by ½ in. thick. When the bed-plates had been set and levelled in their proper positions on the cylinder heads, they were grouted up with Portland cement, and at the same time the bolt-holes were similarly treated, the greatest care being taken to exclude air beneath the plates or in the holes. A general idea of a pier may be gathered from Figs. 7, 8, and 9, which represent the central river pier in end half elevation, side elevation, and plan. The latticing seen in Fig. 8 is not, of course, between the columns, but is at the centre line of the end elevation; and similarly, the central members in Fig. 9 are to be identified with the large cross girders shown at the top of the column in Fig. 7. Each pier column rests upon a cast-iron bed-plate, set as already stated, and planed on the upper surface to a smooth and true face, which is 6 ft. 6 ins. above high-water level. The columns are about 80 ft. 3 ins. long, made up in three lengths of 24 ft. 0⅝ in., 23 ft. 6 ins., and 32 ft. 8½ ins. respectively. The vertical height of the top column is 79 ft. 3 ins., making a total height of 85 ft. 9 ins. above high-water level. A cruciform section, 3 ft. by 3 ft. 3 ins., was adopted for the columns, built up of $\frac{5}{16}$-in. web plates, 6-in. by 4-in. by $\frac{5}{16}$-in. flange angles, and 3½-in. by 3-in. by $\frac{5}{16}$-in. angles at the intersection of the web plates. The column foot is of somewhat more complex construction, as indicated in Fig. 7, and it should be noted that all the feet were planed across the full section after riveting, so as to ensure a true face and the angle necessary for giving the required rake to the columns. The angles and gussets at the feet of the columns were also finished perfectly flush with the column section, and were dressed to form a true plane, so that the whole

FIG. 18.—NEW REDHEUGH BRIDGE, JAN. 29, 1901, SHOWING PORTIONS OF OLD STRUCTURE.

FIG. 19.—OLD AND NEW REDHEUGH BRIDGES DURING ERECTION OF MAIN GIRDER SPANS.

sectional area of the column, with its foot angles and angle gussets, might bear equally upon the cast-iron bed-plates. It was specified that the butt joints in every case should be planed across the full section after riveting in the contractor's yard, so that the joints might bear hard upon each other over the full sectional area; and if any opening-out took place under riveting in position, the joints were to be broken and riveted again after the holes had been eased. In column connections the web plates were connected by covers $\frac{7}{16}$ in. thick, and angle covers 3 ins. by $2\frac{1}{2}$ ins. by $\frac{5}{16}$ in.; and the flanges by covers $\frac{1}{2}$ in. thick, and cover angles 5 ins. by 3 ins. by $\frac{1}{16}$ in. For the purpose of adding to the rigidity of the columns each of them has a series of braces at intervals of about 6 ft., as shown on the elevations (Figs. 7 and 8). These braces consist of angle-bar stiffeners, 3 ins. by $2\frac{1}{2}$ ins. by $\frac{7}{16}$-in. section, bent to shape in a hydraulic press, and riveted on so as to connect the legs of the main angles. The pier bracing includes two vertical members fixed between the centres of the columns on opposite sides of the bridge; these members having flanges formed of two 6-in. by 3-in. by $\frac{5}{8}$-in. angles, joined by latticed webs of $2\frac{1}{4}$-in by $\frac{7}{16}$-in. flat bars, whilst the main verticals are themselves joined by latticed bracing of 3-in. by $3\frac{1}{2}$-in. by $\frac{5}{16}$-in. angle-bars. Horizontal struts extend from column to column, where they are riveted to the main angles, and to gusset plates, also serving for the connection of the diagonal ties. The struts are built up of 12-in. by $3\frac{1}{2}$-in. channels, spaced 3 ft. 3 ins. apart and joined by diagonals of $2\frac{1}{2}$-in. by $2\frac{1}{2}$-in. angle-bars, and the diagonal ties of the main bracing are of 9-in. by $\frac{13}{16}$-in. flat bars, connected to the centre verticals by gusset and cover plates as shown in the end elevation (Fig. 7). All members of the pier bracing were required by the engineers to be perfectly straight, true, and without twist, both after being riveted up in the contractor's yard and after they had been erected in position. Moreover, the diagonal ties were drawn up uniformly tight to take their proper share of stress; and with this object in view the lower ends were drilled in place during erection. In erecting the piers, the bracing

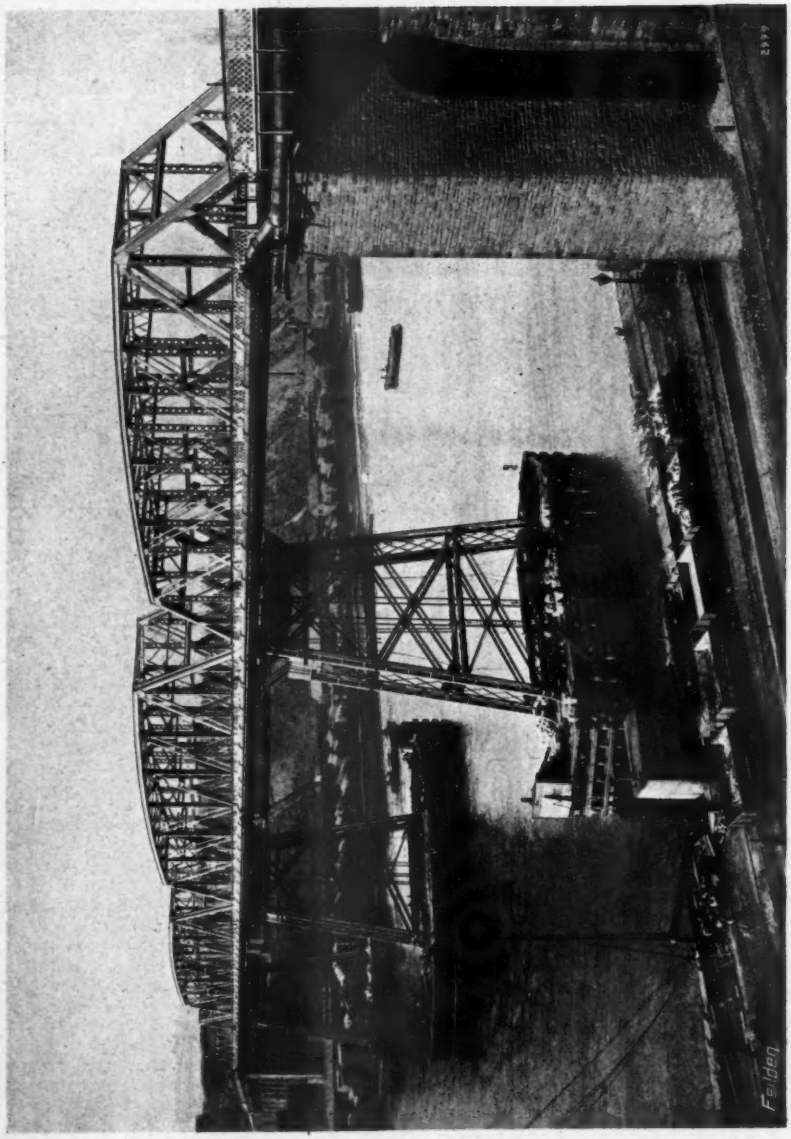


FIG. 20.—THE NEW BEDHEUGH BRIDGE: THE COMPLETED STRUCTURE.

FIG. 21.—LOOKING THROUGH THE NEW REDHEUGH BRIDGE.

between the main columns immediately followed the erection of each column length, and, as far as possible, was riveted up in each length before additional sections of the columns were put in place. As the building up of the piers proceeded, the lattice bracing between the channels forming the horizontal struts of the pier bracing was put in and riveted up, except where portions of the old bridge piers were in the way of the new work, and in all such cases temporary compensation was made to supply the deficiency. Each pair of pier columns is joined near the top by side girders, one of which is to be seen in Figs. 7 and 8. The side girders measure 12 ft. long by 6 ft. 9½ ins. deep by 3 ft. wide; they are built of plates and angles, and include two outer longitudinal members with transverse connecting plates and top plates. The large cross girders resting upon the side girders are 48 ft. long on top by 6 ft. 9½ ins. deep, and four of them are fixed between the columns of each pier. The top edges of the cross girders under the main bearings, and the bottom edges of the same webs where resting on the side girders, and also the top edges of the side girders where supporting the cross girders were made to project about $\frac{1}{10}$ in. above the surface of the flange angles after the latter had been riveted in place. The projecting metal was then chipped down flush with the top tables of the angles, in order to give a perfect bearing for the loads coming upon those parts of the structure. An upper plating, ½ in. thick, extends over the pier column tops, the upper members of the main bracing and the cross girders thus forming a platform for the entire pier-head; and it should be remarked that this was riveted up as far as possible before the bearings were placed in position for the erection of the main girders of the bridge. Bearing strips, as shown just above a portion of the cross girder at the lower part of Fig. 10, were provided for the main bearings. These were riveted in place, and sufficient thickness was allowed to enable them to be dressed in position to a true and coincident level for each pair of bearings. Before proceeding to describe the main bearings in detail we must explain that some of them are fixed and others have rollers, permitting of expansion and contraction. At the centre pier both pairs of bearings are of the fixed type; the two other river piers have each one pair of fixed and one pair of roller bearings, and the masonry piers at each end

are furnished entirely with roller bearings. Taking first a fixed bearing (Fig. 10), as exemplified in the centre pier, we find the lowest part to consist of a rolled steel slab, 3 ft. 6 ins. square by 6 ins. thick, kept in position by 1½-in. turned pins; above the slab are the cast-iron knuckle plates, whose surfaces are planed where they bear upon the steel slab and receive the heel of the main girder. The plates are also accurately bored to fit the knuckle pins, and holes are bored in the top knuckle plate to receive the turned bolts connecting it to the main girder. The knuckle pin is of forged steel, turned for its entire length to 12 ins. diameter, and a hole 2 ins. diameter is bored centrally through the full length of the pin. In the case of a roller bearing the top knuckle plate is as described above, but the bottom plate is of less depth, so as to provide room for the series of six cast-iron rollers. If the rollers were complete cylinders they would be of 10 ins diameter, but as comparatively little movement is necessary, the width of each is reduced to 5¾ ins. They are linked together at their upper ends by means of a steel plate, 3 ft. long by 6¾ ins. wide by 1 in. thick, and 1⅛ in. bolts, and at their lower ends by a plate of the same length and thickness, but only 4½ ins. wide. The top link plate is slotted out in the middle for a distance of 13½ ins. by 2 ins. wide, and the lower link plate has a projection 11½ ins. by 1⅜ in. wide, allowing space for movement. The two plate edges are ¼ in. apart, and the rollers are linked 6 ins. apart centre to centre. Every precaution was taken to ensure the proper distribution of the loads over the whole of the rollers uniformly and with perfect freedom in working, and the final adjustment was performed under the direction of the engineers. At the masonry piers the steel slabs were replaced by cast-iron bed-plates accurately set in position, and their upper surfaces were planed to receive the rollers.

The heel-plates of the main girders of the 248-ft. and 168-ft. spans are of uniform thickness, planed where necessary; and the large flange angles, as well as the lower edges of the gusset-plates at the feet of the inclined end posts, were dressed perfectly true and square, and all flush one with another, to bear accurately for their full area upon the upper faces of the heel-plates. It would be wearisome to our readers if we occupied space by detailing minutiæ of construction relating to the main girders of the spans, but a few general dimensions may probably be of interest. Taking one of the larger spans as an example, we find the total length to be 251 ft., and the depth 35 ft. 4 ins. Part of the inside elevation of one main girder is given in Fig. 11, the lower part of the figure representing the general plan of flooring. The upper booms of the girder are spaced 23 ft. centres apart, being connected by bracing, as shown in Fig. 12, which is a cross section at the centre, and the inclined end posts are joined by lattice work, which may be observed in the photographic views (Figs. 17 and 18). Each of the upper main booms is approximately 191 ft. 6 ins. long by 1 ft. 10 ins. deep by 2 ft. 6 ins. wide, and the sides are built up with 4 ins. by 4 ins. main angles, 20 ins. by $\frac{13}{16}$ in. web plates, connected by 34 ins. by 1 in. top flange plates and lattice bracing of 2½-ins. by ¼-in. flat bars. The construction of the lower booms is somewhat different, having 4 ins. by 4 ins. main angles, 24 ins. by $\frac{13}{16}$ in. web plates, 24½ ins. by $\frac{13}{16}$ in. to 1 in. bottom flange plates, and in addition there are inside main angles, inside cover plates, diaphragm plates and other details The compression and tension members vary in construction, but generally it may be said that the main struts are built up of angles and channels with plate webs, and that the ties are formed of flat bars; but the tie-bars on either side of the centre line are stiffened by the addition of tees in the lower portions, as may be gathered by reference to the continuation of Fig. 11. The other vertical and diagonal members are mainly of lattice construction. In the 168-ft. spans the diagonals of the centre bays were adjusted by means of forged steel couplings, into which the ends of the adjustable diagonals were screwed, pins being driven after erection of the main girders through holes drilled in the correct positions, and the ends of the pins were then riveted over to prevent the slacking back of the couplings. Drain pipes were inserted in the lower booms of all the main spans, through holes drilled in the bottom plates. Cross girders, which are shown in Figs. 11 and 12, are suspended from the lower booms of the main girders, forming supports for the longitudinal joists carrying the roadway and footways, and for the gas and water pipes. Comparatively little interest attaches to the main girders of the approach spans, the general character of which will be gathered from an inspection of Figs. 13 and 14. In the latter some details of the steelwork are shown, and the mode of supporting the gas and water mains is sufficiently indicated.

The main girders were built with the following amounts of camber: 248-ft. spans, 1½ in.; 168-ft. spans, 1 in.; approach spans, none. The under-sides of the heel-plates of the main girders of the approach spans were carefully planed to the taper necessary for

ensuring a true bearing for their full area upon the cast-iron bed-plates at the tops of the masonry piers.

Having now finished with structural details of the various parts of the bridge, it will be instructive to trace briefly the different steps taken in connection with the work of erection. This was commenced in May, 1897, the contract having been let in the month of February in the same year. The western halves of the approach spans at each end of the bridge were first erected in the following manner. All the arches in each approach were centred simultaneously, the arches being relieved of the weight of the roadway and spandril walls, and taken down simultaneously in order to obviate any risk of thrust upon the masonry piers. The old gas and water mains were shored up from the centrings and piers, and the masonry of the piers and abutments was then built up for half the full width of the approaches to the levels shown in Figs. 2 and 15. This being done, the half width of the approach at each side of the river was completely finished and opened to traffic, which had up to that point been carried over the eastern halves. A similar course was next adopted with regard to the reconstruction of the eastern half of each approach. New gas and water pipes were laid on the bearers at each side of the approaches and temporary connections were made to the ends of the old mains on the river spans. Nothing was done in the actual erection of the main girders of the large spans until the approaches had been entirely remodelled. One reason for this was a clause in the specification, and another may be found in the large amount of preparatory work to be done in connection with the cylinder foundations and river piers. Fig. 16 is reproduced from a photograph taken on May 17th., 1898, just about a year after the commencement of operations on the site; and this view will serve to illustrate the manner in which the approaches were treated.

When the proper time arrived for the erection of the large-span main girders they were simultaneously built out as cantilevers from each of the three river piers, and in each case it was arranged that the overhanging ends should balance around the centre of the river pier. The girder heels were carried on the permanent knuckle joints, and in order to erect the main girders and their bracing without imposing any load on the old bridge, the engineers designed a system of erection ties and adjusting gear to connect the ends of the main girders resting on each of the three river piers. These erection ties and their adjusting gears enabled the girders to be erected as cantilevers on each side of the piers, and worked most satisfactorily, it being possible by their help to raise or lower the outer ends of the girders as they were erected so as to bring them exactly into the correct position necessary to meet the ends of the other halves of the main girders built out from the next piers. At the junction of the inclined end posts with the top booms of each girder the permanent gusset-plates were extended and thickened by additional side plates to form eyes at the tops of the inclined end posts, and a series of four ties was secured at one end by pins passing through the gusset-plates and extending nearly up to the end of a similar series connected with the opposite girder. The free ends of the ties were then coupled by pins passing through a pair of steel junction plates, thus forming a linked connection between each pair of opposing end posts. From each set of junction plates two tie-bars descended to and were connected with the adjusting gear, which consisted of a bridge having screwed holes at each end receiving adjusting bars, about 9 ft. long by $2\frac{3}{4}$ ins. diameter, screwed at their upper ends to permit a total travel of 2 ft. 9 ins.; and at the lower end of each adjusting bar was hung a forged bar, passing under the projecting ends of the knuckle pins of adjacent girders. The separate halves of the 248-ft. spans were joined up at the centres of the spans, but the 168-ft. spans were built as cantilevers for their complete length from the river piers to the masonry piers of the approaches. As the moment of an entire 168-ft. span is greater than that of half a 248-ft. span, it became necessary to dispose along the lower booms of the latter a sufficient quantity of ballast to establish equilibrium. On no account was the weight of the new main girders permitted to rest upon the old bridge, and erection had to be conducted so that the new work was supported entirely by the new piers, any assistance given by the old structure being strictly limited to the prevention of lateral movement or of rocking upon the bearings. As the erection of the main girders progressed, the portal bracing, sway bracing, and horizontal wind bracing between the top booms were fixed in position as far as possible; but where this proved to be impracticable recourse was had to temporary bracing. Similarly, the cross diaphragms in the lower booms were bolted in place, with the object of stiffening the spans during erection. Fig. 19 is reproduced from a photograph taken before the completion of the main girder spans. When the closing lengths of the 248-ft. spans had been con-

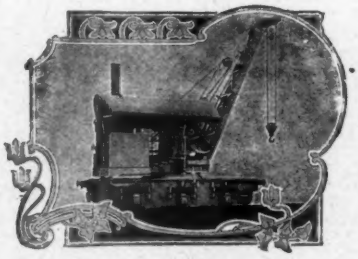
nected, and the 168-ft. spans had been completed, the erection ties were removed, and the main girders took their own weight on the bearings. Turning back to Fig. 4, it is to be seen that the actual difference between the centre lines of the new and old spans, during erection, was about 4 ft. 6 ins.; and, moreover, the new main girders were erected, by the aid of temporary packing under the bed plates, at a slightly higher level than that at which they were finally fixed, with the object of clearing the tops of the old cross girders.

At that stage the position was that the piers of the new structure had been built around the old piers, whilst the new spans rested a little to one side of, and slightly higher than, the old spans. The new spans were then lifted one at a time by hydraulic jacks placed under the projecting ends of the knuckle pins, whilst the temporary packing was removed by degrees, permitting the spans to be lowered gradually. The new cross girders were then riveted up, the new gas and water pipes were laid in position, and connected by temporary joints to the ends of the new pipes on the approach spans. Then the entire structure of the old bridge was removed, and all permanent bracing left incomplete being finally riveted up, the new spans, weighing fully 1,600 tons, were moved over horizontally to their final position. This unique operation was successfully accomplished in a few hours on Sunday, May 5th, 1901, without interruption of the traffic; and when all incidental work had been finished, the permanent expansion joints of the gas and water mains were inserted, and the completion of the flooring joists, plating, hand-railings, and similar details was then undertaken.

Figs. 20 and 21 afford excellent views of the completed structure, these and similar representations being from photographs taken by Mr. W. Parry, of South Shields.

The engineers of the bridge are Messrs. Sandeman & Moncrieff, MM.Inst.C.E., of Newcastle, who are to be congratulated upon the creation of so satisfactory a structure, every detail of which bears evidence of much foresight and engineering skill, and especially upon the ingenious methods adopted in its erection. It is satisfactory to remark that from the commencement of the works, right up to Nov. 26th, 1900, a period of three and a-half years, vehicular traffic was absolutely uninterrupted, and that foot traffic was never stopped. Mr. George Huntley, the resident engineer, proved himself to be thoroughly worthy of the responsible work entrusted to him; and the contractors, Sir William Arrol & Co., of Glasgow, deserve every credit for the workmanlike manner in which the designs of the engineers have been realised.

W. M. Thornthwaite



Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection.

I.—ELECTRICAL ENGINEERING.

Lifting Paving Stones by means of Short Circuits on Town Supply Feeders.—In this case, the feeders were triple concentric, 500 volts, the insulation being one of the paper systems. In making a joint, the workmen had not properly closed up the lead covering on the outer, and moisture had crept through into the insulation. The first effect was, when running on the accumulator, the main fuse was blown, and after this had been replaced next day, the short formed pulled up the engines that were running, practically shutting down the station. When the outside department went to locate the cause of the trouble, they were enabled to do so at once, from the fact that an old lady had been raised a few inches off the ground, and frightened out of her wits, owing to the lifting of a large paving stone. The electrical men said that the trouble was due to gas having ignited there, but it appeared that there was no gas present at that spot, and eventually it turned out that the energetic action was due to the sudden formation of steam from the moisture which had soaked into the insulation, on the passage of the arc which was formed when the short broke.

Burning up a Cable buried in the Ground.—This was in the early days of electric lighting. A cable had been carried across a field from an electric-light station to a church about 600 yards distant, to supply light for the services. The cable was lead covered outside of the insulation, and it was laid simply in the ground, the latter being very damp at times. One Sunday evening, just as the minister was about to commence his sermon, the whole of the lights in the church were extinguished. The minister being a man of resource, and not dependent upon his manuscript, proceeded to deliver his sermon in the dark, and by the time he had finished other lights were brought, and nothing happened so far as the worshippers were concerned. When they came to look for the trouble, however, next day, they found that the end of the cable, where it was connected to a piece of overhead wire, was badly fused. For a length of several yards, the copper conductor, the lead covering, and the insulation formed one mass, the lead having spread itself out in a very unpleasant manner. The cause evidently was, the insulation resistance of the dielectric to sparking, had gradually decreased, owing to the penetration of moisture from the surrounding earth, and at a certain instant, probably when some change had taken place in the circuit, a spark had passed across, leading to an arc, in the usual manner, and the remainder had followed.

More Pavement Lifting, when Short Circuits are on.—It was put down to gas, as usual, and in this case it was gas, and carburetted hydrogen gas at that; but it was not made in the gasworks. It was made under the pavement, out of the insulating material of the cables themselves. The cables were triple concentric, put in on the solid system, and a short occurred at some little distance from the nearest junction-box. The cables were disconnected at the nearest box as soon as the trouble was located, but meanwhile the pavement for the whole distance between the short and this box had been lifted; and it was evident from the conditions that the

lifting was due to the actual conversion into gas of the insulating material and the material used in filling in the solid system. The heat generated by the current passing through the cables on account of the short, and the confined space in which the cables were enclosed, was sufficient to, first, liquefy and then to gasify the hydrocarbons in the insulating envelope and its surroundings, the confined space preventing the liquid from running away when formed.

A Coal Pit set on Fire by the Parting of a Pair of Electric-Power Cables.—The coal-pit was in the county of Durham, and it was a very dry and dusty mine. There was a good deal of water at the face, but the face was a long way from the pit bottom, and there were long lengths of very dusty roads in between. An electric pumping-plant was put down to deal with the water, and it did its work very well indeed; but one day a journey of trams ran over the cables, which had accidentally been allowed to lie on the ground, with the result that the cables parted. An arc was formed between the severed ends, and this ignited the dry coal-dust in the neighbourhood, a very serious fire following. The electric pump was forthwith removed, and has not been used since; and the incident has deterred others from putting electric plants into their collieries.

Testing the Connections of a Drum-Wound Armature.—It was a drum-wound armature, which had been working in an electric motor that had been driving a pump, and it had been sent to a local electrical engineer, who laid himself out for that kind of work, to repair, the coils having been burnt. The armature had been stripped, reinsulated, and rewound, and it was in connecting up that the trouble came. The windings were in two layers, and the coils were displaced 45 degs. in their connection to the commutator. In winding there was no trouble, as the coils followed each other round the core; but when it came to connecting the layers, so that the current would follow in the right direction, there was trouble. The foreman, who had wound armatures of every kind, declared that he fully understood the connections, and declined to be instructed in the matter. In the sequel it appeared that he did not fully understand the matter. It was the connections between the last coil of one layer and the first coil of the next that bothered him. When the armature was put into the machine it declined to furnish any current when driven as a generator, or to convert current into mechanical force when tried as a motor. Careful inspection failed to reveal the cause. The armature was disconnected and reconnected with the same result. Finally a youngster, who had not long been out of his time, suggested a simple method of testing, which he thought would put matters right, the ordinary methods being insufficient. He suggested that what was happening was, the two layers were backing each other, and so no useful effect was produced. If the two layers were tested separately for their magnetic effect upon the core, and then the two connected together, it would be evident where the mistake had been made. The old foreman pooh-poohed the plan, but agreed to try it, as there appeared no other way out of the difficulty. The magnetic test was made by suspending a thin strip of sheet-iron near the armature, so that when the core was magnetised it would be attracted. The test was rather a delicate one, as the attraction that could be produced by means of a battery whose current was sent through the coils of the armature was small, but with care it was sufficient. First, the underlayer was connected up temporarily, so that the current passed continuously through the coils, and its effect on the strip of iron was observed. Then the outer layer was connected up separately, and its effect observed when a current was passing; and then the two layers were connected up together, and the effect observed. As the youngster had foreshadowed, when the two layers were connected as the foreman had previously connected them, no effect was produced on the test strip of iron; when the connections were altered in the way the test showed should be done, and the armature finished off on those lines, the machine worked as heretofore. There is considerable difficulty in testing in a case like this in the ordinary way, as the results of the test might be misconstrued for a short between the two layers.

Trouble with a Disc Armature.—It was a disc armature, which ran between four sets of horse-shoe pole pieces, and it had come into the repairing shop because it had burnt its coils. It had been run by a gas engine. The armature was rewound, put in the machine, but refused to furnish any current. The machine was compound-wound, and it was thought that possibly it was due to the machine having lost its magnetism. It was therefore remagnetised, but with no better result. Considerable time was spent on the matter, and at last the trouble was located in two very small places on the armature windings which rubbed, very slightly, on the

pole pieces, making a short between the two. The rubbing was very slight indeed, and only occurred when the machine got up to its speed, the centrifugal force evidently then causing the conductors to spring out and make contact with the faces of the pole pieces as they passed.

Another Trouble with the Armature of a Four-Pole Machine.—This was an armature in which the opposite coils were connected together, so that one pair of brushes, set 90 degs. apart, answered for the four; and the cross connections were made by means of brass rings strung on the shaft, with projections for the wires to lay in from the different coils, the rings being insulated from each other by asbestos. The machine was also one of those in which there was very little room for anything, especially for insulation, and considerable care and some skill was required in connecting the wires from the coils to the rings. The old foreman was the principal cause of the trouble again. He could not see the use of these brass rings, and he would not be told, so at first he connected the armature up as a two-pole, and it promptly burnt. It was then that the real trouble began. The brass rings having once been taken out of their place, absolutely declined to go back in such a manner that the wires from the coils could be connected to them with any degree of probability that they were not also connected to the next lot of coils as well. Several attempts were made to connect in this way, the old foreman being exceedingly obstinate on the point. "If they went in once they would go in again"; "if another man could put them in, his men could, or he would know why!" But he could not, nor his men, and in the end he had to take advice once more, and put in wires crossing the armature behind the commutator, in the space left vacant by removing the brass rings and their insulation. Eventually this method answered all right.

Short on a Feeder makes a Shower of Copper.—There was a bad short on a 500-volt feeder, and the circuit breaker, instead of operating properly, broke the circuit, but did not blow out the spark. It was one of those apparatus arranged to blow out the spark on breaking circuit, by electromagnetic repulsion. In this case the spark was not blown out. The machine circuit breakers did not operate, as the short was practically off, while the arc was in being, and the attendants did not relieve the feeder by switching current off. They did not think of doing so at first, and were not able to get near enough to the switchboard afterwards. The consequence was, the leaf copper contacts, between which and the stationary contacts the spark passes, were melted and blown over the neighbourhood of the switchboard in a shower of fine pellets of copper; and this went on till the arc burnt itself clear, when it went out in the usual manner.

Running the Excitor of an Alternator as a Generator by means of its own Alternator run as a Motor.—The following is an interesting case, showing how very flexible the system of delivering power by means of electricity is. The alternator in question had its excitor on the same bed-plate, the armature shaft of the excitor and the shaft of the alternator being coupled together mechanically. It was required to run the excitor for charging the accumulators, as no other continuous-current machine could be spared, and the alternator was not wanted. The excitor was first run as a motor, the current being taken from the accumulator charging service. When the alternator, which revolved with the excitor, was at its proper speed and in synchronism, it was switched on to the alternator bus bars, and allowed to run as a motor, driving the excitor as a generator, the latter then delivering its current to the charging circuit of the accumulators.

II.—MECHANICAL ENGINEERING.

Moulding a Double Cylinder.—At Fig. 1 is shown a general view of a double cylinder pattern for a high-speed vertical engine, bore 10 ins. and weight of casting about 18 cwt. The pattern was made in halves jointed at *A B*, moulded in dry sand and cast on end to ensure soundness. In order to expedite the turnout of the castings, a few preliminary preparations were necessary before the moulding commenced. A suitable moulding box having been selected, an open sand casting of a plate, Fig. 2, was made equal in length and width to the top and bottom parts of the box when put together. This plate had numerous "prods" or projections about 1 in. high over the surface on one side, also a couple of holes 1½ ins. larger in diameter than the core-prints on the pattern and coinciding with centres of same. A special form of box runner, Fig. 2, was also made, to be used at each cast and prepared by giving the inside of the runner a good coating of clay-wash, then well

packing all round with 2 or 3 ins. of black sand, the "gates" *G G*¹ being formed with cores, as Fig. 3, by this arrangement the flow of the metal could be regulated. For the moulding, two pieces of 4 in. scantling—a few inches longer than the box—was bedded level in the foundry floor. The surface of sand between was strickled off and freely sprinkled with parting sand, the bottom half of the pattern set in position and the bottom part box placed over it. A layer of facing sand about 1½ in. deep was sieved over the pattern and well packed round it, black sand being used for the other portion to be filled. At intervals of a few inches, short lengths of iron rod dipped in clay-wash were laid, to assist in the binding together of the sand. When the box had been rammed about two-thirds of its depth, a layer of cinders was made into which vents were subsequently made with a rod; these gave a free exit to the gas generated when pouring the mould, outline of the pattern being marked as a guide to the venting. The half box was then turned over, the pieces of scantling upon which it rested being cramped to it, as a preventive to the falling out of the pattern. The joint of the mould was then smoothed and brushed off, sprinkled with parting sand, the other half of the pattern placed over the first and the top part box set over it. The ramming up of the top part corresponded with that of the bottom, with the exception that gaggers were freely used to support the sand in position and special attention given to sprigging the weak places or thin sections of sand. The mould was then parted, the joints brushed off and "swabbed," and the pattern rapped and drawn, after which the mould was "sleeked" with smoothers, the larger surfaces first, the edges of flanges, facings and intricate parts, being dealt with afterwards. Hemp "swabs" were used to give a coating of liquid plumbago blacking, and the thin sections of sand were stiffened with a dressing of core gum. Studs and chaplets were set in position, and the mould was then removed to the stove to be lightly fired and gradually dried in order to prevent the blistering of the blacking. After being thoroughly dried the mould was taken out, dressed off and cored, the chest, port and exhaust cores Fig. 4 being first put together and lowered into the prints by means of a couple of thin leather straps. From these and the jacket cores the air was got away through tubes inserted in the cores and passing to the outside of the moulding box. The mould was then closed, the box pins cottered, turned on its side and the plate, Fig. 2, lowered over the projecting body cores and cramped to the edges of the box. This plate had been covered with loam about 1½ ins. thick and the circular openings reduced to the diameter of the body cores with the same material; four spaces, as *A*, *B*, *C*, *D*, about 2 ins. wide, being left in each for the entrance of the metal as shown. The runner was then set on the top plate and the gates covered with stoppers S to prevent the ingress of the metal to the mould, before a sufficient quantity could be got into the front half of the runner, to maintain a steady flow. When this part was about two-thirds full, the stoppers were lifted simultaneously and excellent castings were the result of this method. The plate and runner served each time with a re-dressing of loam and black sand. The body cores were held down by hook bolts from the bottom, and a section of the mould, Fig. 5, shows the general arrangement. (£1 1*s*.) G. BUCHANAN.

Saw-Sharpening.—Few apprentices in their training receive much instruction in the setting and sharpening of saws, so that a few practical hints on the subject may be appreciated. In the first place it is necessary to have a good saw vice of sufficient length to accommodate the saw without having to move it along two or three times, whereby the operator loses his position of angle. The length of such a vice should be about 28 ins., and provided with two hinged clamps for securing it to the bench and also for tilting it to any desired angle. The different angles and positions for filing are dependent upon the kind of saw we are about to sharpen. For cross-cut saws the vice at an angle of 30 degs. from the vertical allows the file to be kept parallel to the horizon and held at the same time towards the operator at about 60 degs. with the blade. For a little time, until some degree of proficiency is acquired, a few chalk marks on the bench at 60 degs. are of considerable assistance. The filing of the teeth to these angles gives a sharp cutting edge and a point which removes the fibre of the timber on the edges of the cut before the full width of the tooth comes into operation. An approximate angle is easily obtained by keeping the cuts on the ordinary triangular saw-file parallel to the face of the blade. Keep the points of the teeth of one height, and should the blade be hollow, reduce the high points with the flat of the file; then file them up until all are level. This gives uniform cutting for each tooth. Begin at the right-hand and work towards the left; be careful not to file too much off one side, or the result will be teeth of unequal length. Rip saws are usually filed on the one side and held vertical in the vice. Band-saw teeth are vertical on the front or cutting side, with an angle of about 30 degs. on the back. These are generally supported by stretching them between a couple of wooden discs, fixed by centre bolts movable in a slotted bar to the varying lengths of the bands, the vice gripping the saw midway between the discs. The setting is either done with a hammer on a block with inclined edge, or the teeth are brought under a punch held in a frame which sets them on both sides. Another form of set is one having a ram which presses against the saw blade, a separate ram, which is alterable, putting on the required set. These sets are in the form of pincers, and are held on the sides of the blade against each alternate tooth. One-third of the tooth-depth may be taken as the distance from which the set or bend begins, and some little judgment is required in this operation, owing to the variation of temper and the tendency to snap off the teeth in hard saws. E. T. WIRES.

[NOTE.—The modern saw vices, which are ball-jointed at bottom, can be arranged and held in any direction.—ED.]

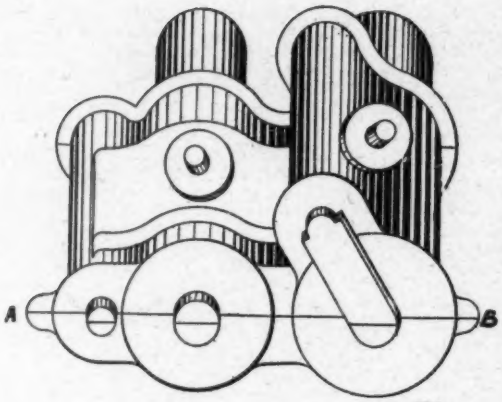


FIG. 1.

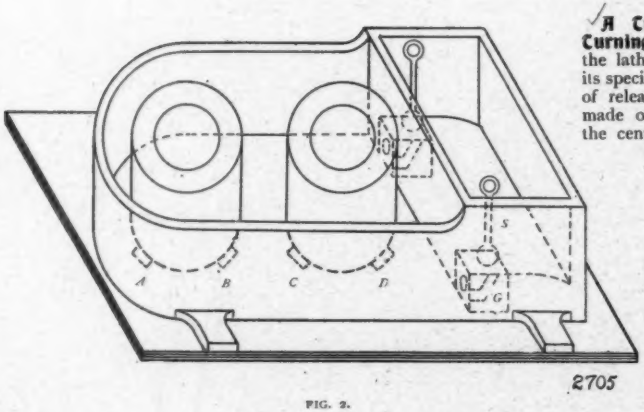


FIG. 2.

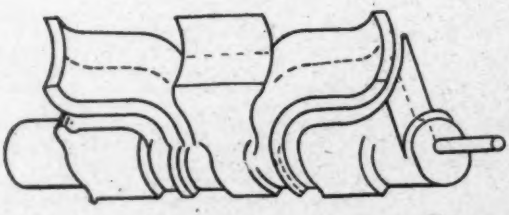


FIG. 4.
MOULDING A DOUBLE CYLINDER.

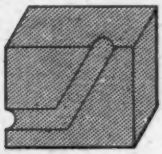


FIG. 3.—SECTION OF "GATE" CORE.

Double Drive from a Single Pulley. — A method of utilizing a single pulley on the main shaft to drive two machines is shown at Fig 1. The main shaft *A*, situated below the floor line, communicated motion to the machine *B* by a direct drive. An additional machine being required, want of space prevented the fixing of another pulley on the main shaft. The difficulty was eventually solved by superimposing a second belt from pulley *A* over *B* to *C*.

DAVID HORSBURGH.

[The speed of the second machine would be somewhat accelerated by this arrangement.—ED.]

A Travelling Stay for Shaft Turning.—A stay which is bolted on the lathe carriage is shown at Fig. 1, its special feature being the easy method of release. The body of the stay is made of cast iron, with provision in the centre for carrying a hard wood step—the grain of the timber running in an upward direction to ensure best wear—with a setting-up screw on the under side. A cast-iron lever pivoted in the stud *S* and provided with a top step of hard wood is depressed by the screw *D*, thus preventing any jar during the cut. On the completion of the work the screw is slackened, and the round shank on the stud allows the lever to be swung out of the way.

A. T. METCALF.

An Improvised Pipe Wrench —A very efficient substitute for a pipe wrench may be made with an ordinary spanner, if a wedge-shaped piece of steel be used in the space between the eye of the spanner and the stud or pipe which is being screwed into place. The wedge, Fig. 1, should be about 1¼ ins. long by ¾ ins. wide, tapering from ⅜ in. to ⅛ in., toothed on one side as shown, and tempered to a dark straw colour. Fig. 2 shows the application

ARTHUR SPEIGHT.

[A short piece of round steel is also an alternative to the wedge —ED.]

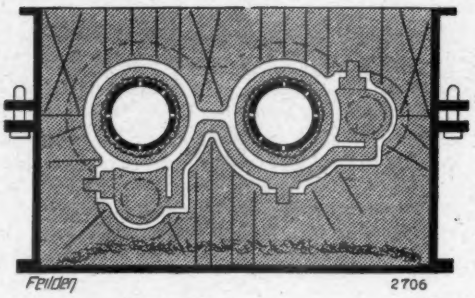


FIG. 5.
MOULDING A DOUBLE CYLINDER.

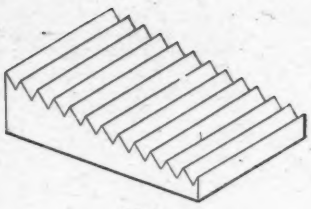
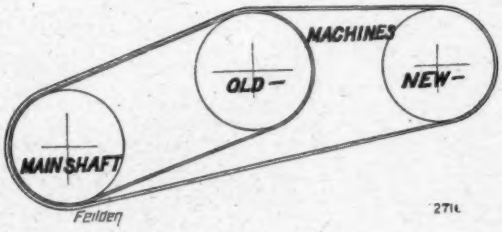


FIG. 1.



DOUBLE DRIVE FROM A SINGLE PULLEY.

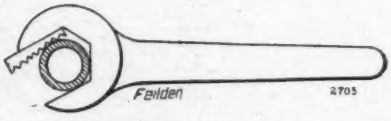
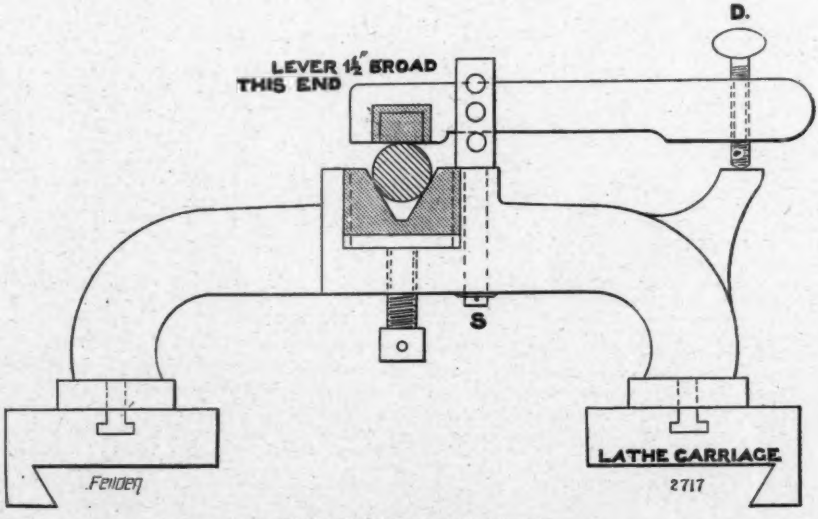
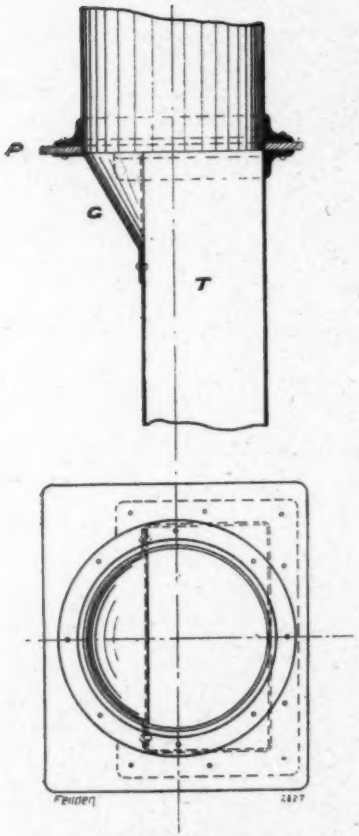


FIG. 2.
PIPE WRENCH



TRAVELLING STAY FOR SHAFT TURNING.



FIGS. 1 AND 4.

Sheet Metal Work.—The illustrations Fig. 1, 2, 3 and 4 show a piece of sheet metal work, and the method of connecting a rectangular tube with a cylindrical one, both having the same area. This particular example is most frequently met with in the arrangement of ship's ventilators, from above deck to stoke-holes, engine-room, etc., and upon the cylindrical part of the tube is mounted the cowl, which may be swivelled round in any direction. In order to make a good finish, a rectangular plate, *P*., Fig. 1, is interposed between the two sections and serves to carry the angle iron frames to which the tubes are riveted. The setting out of a knee-piece or gusset is sometimes a rather difficult job for an apprentice or journeyman who has but an imperfect acquaintance with geometry and mensuration, as the incorrect development of the plate causes a great deal of trouble and at all times presents an unsightly appearance, either by having an irregular margin, or kinks caused by trying to make it fit into position. The correct development of the gusset *G*, Fig. 1, is a hyperbolic curve, formed by the penetration of a cone—of which the gusset forms a portion—by a rectangular prism, as the tube *T*, and the laying out of which is as follows: Set out a side elevation, Fig. 1, showing the connecting gusset, and for convenience of measurement set out a cone, Fig. 2, with the base diameter and inclination of the sides the same as that of the piece *G*. From *D* as a centre, with radius *DB*, describe semi-circle *BC*. Draw line through *EF* coinciding with the line of penetration or face of rectangular tube.

Draw radial lines *a*, *b*, *c*, *d*, *e*, *f*, *g*, through sector *BE*. Describe arcs from centre *D* at points of intersection on vertical plane *EF*, and radial lines. Erect perpendiculars from these points on line *CB* 1 to 7, cutting line *AB*. With radius *AB* from centre *I*, Fig. 3, describe an arc; make *GH* equal in length to *BE*, draw radial lines as 1′, 2′, 3′, 4′. Set off on these lines, from centre *I*, distances equal to *AF*, *A*1 to *A*7. Through these points draw the curve as shown, thus producing the correct development on one side the centre-line of plate. A suitable margin must be allowed for rivets, and the plate is then sheared, rolled and flanged, and afterwards drilled. A plan of the tubes is shown at Fig. 4.

ISAAC POOTS.

Extension to Slotting Machine.—Having to slot keyways in a number of pulleys, larger in diameter than our slotting machine would accommo-

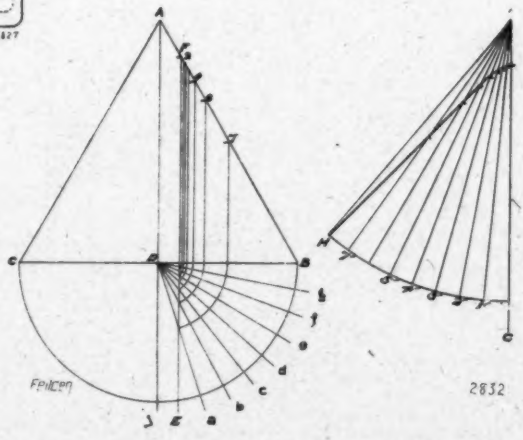
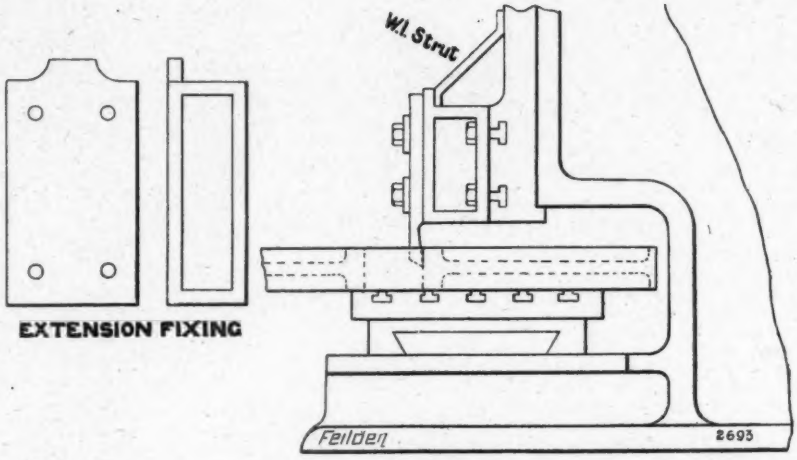


FIG. 2. FIG. 3.

STEEL METAL WORK.



EXTENSION TO SLOTTING MACHINE.

date, we designed an extension, as shown, to overcome the difficulty. A cast-iron box, with open sides, was bolted to the ram of the machine, holes having been drilled to suit the T slots. Studs fixed in the front of the casting and furnished with a couple of clamp plates held the tool, and the addition of a wrought-iron strut 1¼ in. by 1 in. section, secured by a couple of set screws, kept the whole arrangement perfectly rigid.

T. H. FOULSON.

The Proper Arrangement of Quarter-Twist Belts.—In considering the relative directions of rotation of belt-driven shafting, two non-intersecting shafts at right angles may be combined in two different ways. These are shown in Figs. 1 and 2. Any two actual shafts, if looked at in a particular direction, will be represented either by Fig. 1 or by Fig. 2. For each of these combinations there is only one method of arranging the pulleys and belt for a drive without guide pulleys. Fig. 3 shows the arrangement for the combination of shafts indicated in Fig. 1, while Fig. 4 illustrates that corresponding to Fig. 2. In each case four views are given. If Fig. 1 be considered to be a plan, then the four views in Fig. 3 are four elevations taken in order at right angles to each other. The four views in Fig. 4 correspond similarly to Fig. 2. If the upper pulley be the driver, the side of the belt marked T is, in all the views, the tight side. The lower pulley may, however, equally well be the driver. In that case the pulleys will revolve in the same directions as shown, but T will indicate the slack side of the belt. The exact positions of the pulleys on their shafts should be ascertained by trial as they are affected by the relative sizes and relative distance apart of the pulleys. The general arrangement is to make the tangent from one pulley overlap the breadth of the other about two-thirds.

R. M. NEILSON.

[NOTE.—The one condition to be observed in the arrangement of pulleys of this kind is that the point where the belt leaves each pulley shall be in the plane of the other pulley. The illustrations are held over this month for want of space.—ED.]

❀ ❀ ❀

The purport of this section of FEILDEN'S MAGAZINE is to give the skilled mechanic an opportunity of bringing his practical ideas and experience into print. Inventive capacity and careful thought on the part of the workman is what we desire to encourage and foster. To this end we invite practical suggestions, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice, as, when draughtsmanship is at fault, we will do all that is necessary to render them fit for publication. Nothing will be too poor for a careful inspection.

ONE GUINEA WILL BE PAID FOR WHAT, IN THE OPINION OF THE EDITOR, IS THE BEST CONTRIBUTION OF THE MONTH.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

IRON AND STEEL.

Ingot Making.—An improvement in the final operations of the process of ingot making has recently been patented, and is said to have given perfect satisfaction during practical tests. Like that of most of the successful innovations of recent times in manufacturing methods, its object is to reduce to a minimum human participation in the actual work, and to render it possible for every detail to be automatic. Ere the alteration introduced by this new device was made, the process of ingot making was quite satisfactory during the earlier stages—*i.e.* until the ingots, after their passage between the reducing mills, had been reduced to a cross-section so small as to require in being turned the assistance of attendants, who, by means of tongues, supplemented the action of the mechanism. The improved device permits the ingot to be turned even when greatly reduced, and renders the process automatic practically until the ingots have received their finish. This is accomplished by a very slight change, consisting in providing the inner vertical side of the usual stationary horizontal side-plates with a number of projections, or lugs. After the ingot has been turned by the usual means and reduced to the size in which it is no longer easily treated in the same way, these lugs come into play. The reduced ingot is first moved laterally so as to bring the outer upper edge thereof under the projections. The manipulations are then adjusted to bring their upper corners under the inner bottom corner of the ingot, so that when they are raised that side of the ingot will likewise be raised and will make one-fourth of a revolution. After the ingot has thus been turned, the manipulators are operated to move it again laterally into line for the next reduction, and so forth. This arrangement has not only given complete satisfaction where it has been tried, as regards accuracy and certainty, but, by rendering unnecessary the presence of attendants, has resulted in a considerable saving of time and labour.

Liquid Steel Compression.—An interesting method for compressing liquid steel, so as to prevent the formation of pockets and flaws during manufacture, has recently been patented in the United States by M. Henri Harmat, of St. Etienne, France. The compression takes place in a mould of frusto-conical shape, with a movable bottom, and a cover fitted inside. Into this mould, which is placed in a vertical position, with its greater diameter at the bottom, the liquid steel is poured and the movable bottom is pressed upward while the cover is pressed downward, though with less force than that acting upon the bottom. By this arrangement lateral expansion is avoided, because the metal, while the contraction becomes more accentuated and as the ingot mould expands, is pushed towards the smaller base of the conic mould and is constantly pressed against its walls, flowing parallel to the axis of the cone. At the same time it secures the laminating, or drawing, of the steel, which, in consequence of the pressure exerted upon its larger basis, slides axially, not only pressing against the walls, but restricting and diminishing its section in proportion to the pressure that forces it to penetrate more into the narrow portions of the conic mould. Thus, by abolishing lateral expansion and replacing it by the drawing of the metal, the formation of pockets and the tendency of cracking are avoided. The pressure required in this process is not very great, because it is aided by the conical shape of the ingot mould, while the time during which this pressure is to be continued varies with the kind of steel treated, depending on its greater or lesser tendency to crack, and with the mass under treatment; but it need not be greater than the time required for completing the cooling of the ingot.

Hardening Steel Tools.—The point of greatest importance in hardening steel tools is to maintain them at an equal temperature. For this purpose they must be sufficiently large to allow, in front of and behind the tool to be treated, a free space of 150 mm. Supposing, for instance, the tool in question to be a boring-tool 200 mm. in length, the hardening space should have a length of at least 500 mm. to 600 mm. According to *Stahl und Eisen* M. Otto von Geutsch, of Magdeburg, has recently patented a simple and practical oven for the hardening of tools. This oven, which is heated by gas coke, is furnished with a chimney that draws well. It is made in various sizes; type No. 2 has a height of 200 mm., a width of 340 mm., and a length of 600 mm. Its price is £6 12*s.*, and it consumes during ten working hours a quantity of gas coke worth about 1*s.* 6*d.*, while if a charcoal fire be used the expenditure would amount to at least 10*s.*, which shows that the cost of the oven will soon be recovered from the saving in fuel. The *modus operandi* is as follows: The tool to be hardened is coated by means of a

brush with a layer of a special hardening paste which supplies to the steel when heated that quantity of carbon which its structure permits it to absorb. A finely granulated steel of superior quality will absorb less carbon than a coarser and cheaper kind, and the latter becomes greatly improved by the treatment with the hardening paste. In cases in which various grades of steel have entered into the composition of tools this treatment with hardening paste produces a tool equal in quality throughout. The tool, when red-hot, is plunged successively into three baths—first into water containing chalk, afterwards into a bath of colza oil, and, finally, into a bath of petroleum. The employment of these three baths forms an essential portion of Mr. von Geutsch's process. After the tool has been turned a given number of times in the first bath, depending on its size, it has become very hard, so hard, in fact, that in the second bath the tempering of the steel no longer proceeds as heretofore from the outside toward the inside, but, in consequence of the heat in the interior, from the inside to the outside. Thus not only the subsequent tempering is done away with in the new process, but a guarantee is given that the tools neither break nor tear in the hardening operation. Under the auspices of the Royal Ministry for Railroads tests were made in the central workshop at Buckan last year for the purpose of comparing the quality of tools made from the finest Boehler steel, and others made from the much cheaper "Bismarck" steel, hardened by the new process. The result was that ere three weeks had elapsed it had been conclusively shown that the edge of the latter was from 25% to 30% superior to that of the Boehler steel tools hardened by the older process.

Motor Cars in Railway Service.—The Administration of the State Railways in the kingdom of Würtemberg deserves credit for a series of tests extending over several years, inaugurated with the object of ascertaining whether there is any advantage in using motor cars propelled by petroleum, steam, or electric accumulators for passenger traffic within short distances. Although statements regarding the results have, unofficially, been published from time to time, the following data, taken from the official report recently published by the Traffic Department under control of the Ministry for Foreign Affairs, will be of interest to our readers. They refer to the fiscal year of 1899 (March 1st, 1899—April 31st, 1900). The motor cars under trial during that period were: one Daimler motor wagon (No. 1) on four wheels with seats for 24 passengers; two Serpollet steam motor wagons, both four-wheelers, No. 1 with 30 seats and No. 2 with 40 seats; and one motor wagon on eight wheels propelled by electricity furnished by accumulators. The results obtained were as follows:—The Daimler motor wagon, during the period from April 1st, 1899, to March 31st, 1900, was in service 292 days, and covered an aggregate of 43,800 kilometres, at a cost of £209 1*s.* for material and of £131 14*s.* for labour, *i.e.* wages for the driver, altogether therefore of £340 15*s.* This is equivalent to a cost per kilometre of 1·8*d.*, of which 1·1*d.* are for material and 0·7*d.* for labour. To this must be added for ordinary maintenance £54 3*s.*, and £90 for repairing, *i.e.* 0·8*d.* per kilometre. The Serpollet steam wagon No. 1, which was not in use from January 18th to March 31st, 1900, owing to a thorough repairing and improvements being required, covered in 196 days 23,595 kilometres. The fuel consumed was wood, equivalent in calorific value to 3.375 kilogrammes of coal, and 62,000 kilogrammes of coal, *i.e.*, together 65,375 kilogrammes of coal, *i.e.*, 2·67 kilogrammes per kilometre. To this has to be added 234 kilogrammes of oil, equivalent to 0·01 kilogrammes per kilometre. The cost of this fuel amounted to £67, *i.e.*, 0·5*d.* per kilometre. The current expenditure for maintenance amounted to £106 18*s.* 0*d.*, *i.e.*, a little over 1*d.* per kilometre. The other Serpollet wagon (No. 2) was placed into use in January, 1900, coming fresh from the factory. This wagon covered, in 66 days, 7,756 kilometres. The expenditure for fuel amounted to a quantity of wood equal in calorific value to 1,500 kilogrammes, to 25,350 kilogrammes of coal, *i.e.* altogether 26,850 kilogrammes of coal, equivalent to 3·26 kilogrammes per kilometre, while the quantity of oil used was 97 kilogrammes, *i.e.* 0·012 kilogrammes per kilometre; the total cost being £26, *i.e.* 0·7 of 1*d.* per kilometre. To this has to be added £8 3*s.* 0*d.*, *i.e.* 0 6 of 1*d.* per kilometre for maintenance.

The electric motor wagon, which was out of use until toward the end of October, as a new accumulator had to be put in place, and a few alterations were required, has covered 7,927 kilometres with loads, and 116 kilometres empty, *i.e.* 8,043 kilometres all in all. The electrical energy expended amounted to 6,873 kilowatt-hours, at a cost of £81 12*s.* 0*d.*, to which one guinea has to be added for 34 kilogrammes of lubricants, totally, therefore, of £82 13*s.* 0*d.*, which is equivalent to about 2·5*d.* per kilometre. The current cost of repair of the wagon amounts to £17 17*s.* 0*d.*, *i.e.* 0·5 of 1*d.* per kilometre. The maintenance of the accumulators, during the year referred to, was still in the hands of the makers, who, according to agreement, received a round sum of 0·9 of 1*d.* per kilometre, £31 14*s.* 0*d.*, therefore, in all. The total cost of maintenance consequently amounted to 1¼*d.* per kilometre.

Efficient Refuse Destructors.—A large party of gentlemen interested in the problem of refuse destruction, and including representatives of the Councils of Newcastle, Tynemouth, Sunderland, Stockton, Thornaby, Durham, Darlington, Bishops Auckland, Shields, Consett, Long Benton, Southwick, and other places, paid a visit recently to the towns of Nelson and Colne, in Lancashire, for the purpose of personally inspecting the working of refuse destructors for which the makers claim the combined advantages of destroying refuse in a manner and with a thoroughness satisfying the most stringent demands of sanitary experts, while at the same time producing steam for industrial

purposes. The installation at Nelson consisted of a Meldrum "Simplex" Destructor and power plant, while at Colne a Beaman & Deas Destructor were installed. The right of building the latter type of destructor, however, though differing from the "Simplex" in the method of working, has been bought by Messrs. Meldrum Brothers, so that this firm has a monopoly in turning out two of the most efficient types in the market. At Nelson, a town with a population of 33,000, the total quantity of refuse accumulating per annum amounts to about 6,991 tons, and this quantity is disposed of by the "Simplex," a destructor of the regenerative type, within 278 working days, which is equivalent to about 25 tons per day of 24 hours. Practical experience has shown that the quantity of water evaporated by using this refuse as fuel amounts to 432 gallons per hour, and by calculation on the basis of 20 lbs. of water per horse-power per hour, it appears that after deducting the steam used for producing the forced draught and for driving the mortar mills connected with the plant, there remains still 176 horse-power per hour available for profitable investment, as, for instance, electric lighting, traction, or similar purposes. In fact, a lighting and traction plant in connection with the Meldrum destructor plant at Nelson is to be erected in the near future, and the profits derived from this, together with the price obtained for the clinker, *i.e.* the slag remaining after the burning of the refuse, which is ground up in the mortar-mills above-mentioned—will soon reduce the actual cost of refuse destruction to a minimum. The plant at Colne is, as stated, of the Beaman & Deas type, the destructor being fitted to a water-tube instead of a Lancashire boiler, and the refuse is tipped directly from the carts into the drying chamber, instead of having to be shovelled in, as in the Nelson plant. Among other differences may be mentioned that in Colne a fan is used for supplying forced draught to the furnace ashpits, while at Nelson the Meldrum steam jet blowers are used. The cost of refuse destruction at Colne, including the payment of interest on the capital invested per ton, amounts to 10¾*d.* The visitors were given an opportunity of inspecting both plants, and it may be anticipated that their visit will be of benefit to the districts represented by them, since the information gathered at Nelson and Colne will aid them in selecting those means of refuse destruction that are best suited to the local needs.

Leicester Tramways. — The new electric tramway scheme for the town of Leicester has now been unanimously adopted by the Town Council in its complete shape. The vexed question of the building of a separate central power-station and its site had led to a difference of opinion between the members of the Council and the Mayor, the former advising that the Lero on the Belgrave Road should be adopted for the purpose, while the latter strongly urged the adoption of the Aylestone Road site. At the last meeting of the Council, in which the question was under discussion, the Mayor, though not surrendering his opinion, gave way to the Council, and frankly wished them every success in their undertaking. As a result of this settlement, the original scheme, prepared by Mr. Mawbey, M.Inst.C.E., the Borough Engineer and Surveyor, from whom also the recommendation of the separate central station emanated, was adopted unanimously, in perfect agreement with the view of Mr. E. Manville, the Consulting Electrical Engineer, who on two previous occasions had expressed his approval of it. The necessary plans and estimates to be deposited in Parliament are in course of preparation, under the supervision of the Borough Engineer. The committee will do well, however, although for the moment in perfect agreement regarding the details of the scheme, to listen to the advice of the Mayor, "to take all the power that Parliament will give them," to effect any deviation which may be considered advisable after further consideration of the experience of other public bodies during the course of construction of similar undertakings. One of the conditions to be fulfilled, however, before the new electric line can become an accomplished fact, is the acquisition by the Corporation of Lecicester of the present tramway system. This acquisition has been sanctioned already at the price of £134,000, which, after various negotiations, has been accepted by both parties as fair and equitable, so that nothing else is to be done until after the sanction of Parliament has been obtained.

Corundum Deposits. — Corundum is undoubtedly, for many purposes, far superior to emery, owing to its high abrasive powers. Its use, nevertheless, has, so far, been restricted, owing to its high price, the necessary result of its rarity and the expenses frequently incurred in mining it. It appears, however, that this mineral will, in the near future, be placed upon the market at a greatly reduced figure, for it is stated on reliable authority that considerable deposits of corundum have been discovered in the province of Ontario, Canada, easy of access, and easily worked. In these deposits corundum is found in connection with mica and other substances, from which it has to be separated by washing, which, owing to its great specific weight, offers but few difficulties. Data are lacking as regards the exact extent of the deposits, which are situated north of Kingston, but the quality, to judge from the specimens so far tested, seems to be unusually rich, and a company has been formed with sufficient capital to develop the deposits. As is always the case when corundum is found, hopes have arisen that its near relations in the mineral world, ruby and sapphire, may occur in the neighbourhood; but, so far, there are no signs of these hopes being fulfilled, unless the fact that some of the specimens show plainly the blue line of the sapphire are to be taken as such. In any case, however, the discovery is of considerable interest, as Canadian corundum found heretofore has been of a very high grade, and the Canada Corundum Mining Company are producing corundum 95 per cent. pure, while the mineral found elsewhere rarely runs higher than 80 per cent. pure.

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In this section is presented every month a concise précis of the contents of the leading organs of the technical press and of the proceedings of the learned societies throughout Great Britain, the Continent, and America, and also, in a summarised form, the subject matter of the more important articles appearing therein.

This systematic record should prove of the greatest value to those of our readers interested in one or more specific sections of technology, trade or economics, or to those who have insufficient leisure to peruse the large number of publications now appearing.

In most cases where publications are not readily procurable, with the exception of Transactions of the Learned Societies, copies of the articles can be supplied on application by remitting 7d. Should any of our readers desire further information we shall be happy to supply it.

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ARCHITECTURE AND BUILDING.

1. Construction and Design.

American Architecture.—*Recent Progress in Architectural Design in the United States.* Under this heading is reproduced the bulk of a paper by Mr. Walter Cook, F.A.I.A., read at the 34th Annual Convention of the American Institute of Architects, in which the author expresses the opinion that within the last two or three years a marked growth of distinctly local character in the architecture of the principal American cities is perceptible, which he justly calls a healthy sign, and repudiates the statement of Professor Warren, of Boston, that the influence of the École des Beaux-Arts is so dominant that much of the work seen in the United States is direct importation of French style, with all its mannerisms and often its bad taste.—*Builder*, Aug. 24th, pp. 171, 172.

Cathedrals.—*Ely Cathedral.* Description of one of the most striking and interesting Gothic cathedrals in existence, whether we consider its general aspect or the details of the ornamentation, taken from a monograph by the Rev. W. D. Sweeting, M.A., and published as one of a series of handbooks devoted to English cathedrals, by Messrs. Bell and Sons.—*British Architect*, Aug. 23rd, pp. 126-28. (Ill.)

Church Architecture.—*Truro Cathedral.* The article deals with the slow but steady progress that is being made in the work at Truro Cathedral, and states that the architectural conception of the late J. L. Pearson, R.A., is receiving more complete representation. Preparations are being made for the construction of the great central tower, for which Mr. J. H. Dennis has made a donation of £15,000. The building will be no easy task, as may be realised when it is stated that about 2,000 tons of stone and other material will have to be hoisted for its erection.—*Builders' Journal*, Aug. 7th, 1901, pp. 515, 516.

Construction.—*Construction in Fortified Concrete.* By Alaric Hope, Assoc.M.Inst.C.E. The author describes lucidly the most important methods of fortified concrete construction, beginning with that of M. Moniex, which is the basis of most of the others. In his description it is taken for granted that the metal used is steel and the matrix Portland cement, although there is no reason for not using different but similar materials. In conclusion, enumerating the various undoubted advantages of this new form of construction, he expresses his doubts regarding the justification of M. Hennebique's emphatic claim that his constructions are "indestructible and absolutely fire-proof," and points out that it has been stated by many engineers that concrete will not undergo great heat and still less sudden cooling.—*Transactions of the Liverpool Engineering Society*, Vol. xxii., pp. 61-78.

Mongolian Buildings.—*Notes on Selgukian Architecture.* By Rev. J. E. White, of Marsivan, Turkey. The author gives an interesting account of vanishing remnants of buildings of stone scattered over Asia Minor, and constructed from 400 to 800 years ago by the Seljuk Turks.—*Builders' Journal*, August 28th, pp. 22, 23.

Rustproof Steel Buildings.—*Fireproof and Rustproof Construction.*—Under this heading reference is made to what appears to be an important article, contributed to a magazine called *Insurance Engineering*, recently published in the United States by Mr. Frank B. Abbott, and reviewed in the *American Architect*. The author of this contribution dwells on the serious danger to which modern steel-frame buildings are exposed through corrosion, and among other valuable instructions points out what may not be known to all our readers, namely, that metal to be embedded in masonry or concrete should be entirely free from paint, so that the cement from the surrounding concrete or masonry, if this is grouted where it touches, as it always should be, may attach itself to the surface and form a coating that defies oxidation, while paint slowly disappears, leaving a crevice between the steel and masonry into which moisture can easily penetrate, setting up corrosion.—*Builders' Journal*, August 7th, p. 529.

Stack Building.—*The Practice of Stack Building and Boiler Setting.* By John G. Dunn, Instructor in Building Construction. This is an abstract of a paper read before the Glasgow and West of Scotland Technical College and Architectural Society, in which the author describes in detail the work to be done, and treats in a very instructive manner a subject of equal interest to the architect and engineer.—*Builders' Journal*, Aug. 7th, 1901, pp. 525, 526.

CIVIL ENGINEERING.

1. Bridges.

Arch Bridges.—*Stone Arch Bridges recently constructed on the Fitchburg Railroad.* By Albert S. Cheever, Member Boston Society of Engineers. The author describes five interesting stone arch bridges constructed on the Fitchburg Railroad, U.S.A., within the fifteen months anteceding December last year. The

construction of these bridges instead of steel bridges was primarily due to the high prices of structural steel prevailing during the year 1899.—*Journal of the Association of Engineering Societies, U.S.A.*, July, 1901, pp. 1-9. (Ill.)

Bridge Piers.—*Rebuilding of Pier No. 4 of the Aqueduct Bridge, Georgetown, D.C.* The bridge referred to was built during the years 1835 to 1840 to carry the Chesapeake and Ohio Canal across the Potomac. In 1887, the superstructure having been removed, the substructure was used to support a United States highway bridge. In 1893 several of the piers were found to be in a dangerous condition, and a contract for repairing them was made with the Shailer-Schwiglan Company, of Chicago. Pier No. 4 offered special difficulties. In May, 1899, after it had been repaired and practically rebuilt several times, a new contract for rebuilding it was awarded to the Central Contracting Company, New York, whose interesting work is described under the above heading.—*Engineering Record*, Aug. 1st, 1901, pp. 125-7. (Ill.)

Bridges.—*New Bridge over the Rhine.* Description of an important bridge across the Rhine at Worms, opened to traffic toward the end of last year, together with an outline of the working details, sufficient to enable the reader to form a practical estimate.—*Engineer*, July 26th, pp. 85-7. (Ill.)

2. Canals, Rivers, and Harbours.

Canals.—*Design for a Controlling Works at the Chicago Drainage Canal.* By Ossian Guthrie, M.W.S.E. In this paper the author describes a plan for controlling works for the drainage channel, to be located near the junction of the channel and river, designed by him for the purpose of maintaining a uniform current which the pilot may learn to navigate so as to avoid accidents to vessels, to afford immediate relief to vessels jammed across the river and held by the current, and to afford prompt aid to vessels stranded upon the tunnels.—*Journal of the Western Society of Engineers*, Feb., 1901, pp. 41-51. (Ill.)

River Dredging.—*Dredging on the River Ribble.* By A. F. Fowler, M.Inst.C.E., M.I.Mech.E. The author gives an account of the river dredging operations of the River Ribble, which are of great importance to the Port of Preston, which includes the River Ribble and estuary and its tributaries, all of them being under direct control of the Preston Corporation. Speaking of the operations as a whole he stated that a total of 6,549,631 cubic yards have been lifted, and the navigable depth has been increased from 10 ft. 6 ins. in 1882 to 18 ft. 6 ins. in 1900, therefore only 8 ft. of the 18½ ft. estimated for in 1883 has been obtained, the reasons being lack of funds during the years 1894, 1895, and 1896 but above all the difficulty of removing sand washed up from the lower estuary by the quick-running flood tide.—*Transactions of the Liverpool Engineering Society*, Vol. xxii., pp. 11-17.

River Improvements.—*The Improvement of the Chicago River.* Under this heading is published a very important and interesting set of addresses read at this year's Annual Dinner of the Western Society of Engineers, Captain R. W. Hunt being in the chair. These addresses include a concise statement of the importance of the subject for Chicago, by Mr. L. E. Cooley, who inaugurated the enterprise of purifying the river; an address by Mr. P. B. Weare on the commercial aspect; another by Judge O. N. Carter on the legal aspect; an address by Dr. A. R. Reynolds on the sanitary aspect; followed by Mr. J. C. Braden stating the view of the Drainage Board; by Mr. Wm. N. Chadwick, representing the interests of the grain-shippers; by Mr. Isham Randolph, the chief engineer of the Drainage Board, and other experts.—*Journal of the Western Society of Engineering*, February, 1901, pp. 1-26.

ELECTRICAL ENGINEERING.

1. Theory.

Asynchronous Motors.—*The Asynchronous Induction Motor or Generator, with a Power Factor of Unity.* This is a translation from an article in the *Elektrotechnische Zeitschrift*, contributed by Alexander Heyland, who describes a method of producing the interesting and desirable result of eliminating the well-known phase-difference between current and pressure induction motors, and thus at the same time doing away with the wattless magnetising and light-load currents and the consequences of air-gap between stator and rotor of these motors.—*Electrician*, Aug. 16th, 1901, pp. 627-8.

Interpolar Induction.—*The Interpolar Induction and Distribution of Copper in the Armature of a Siemens 12-Pole Alternator.* By Prof. Ernest Wilson and Wm. Marden. The authors describe experiments, and their results, undertaken at King's College, London, with the object, first, to find the distribution of induction between the two opposing pole-pieces in a given machine when the air-space length was varied and the exciting current kept constant; second, to examine the effect of variation of air-space length upon leakage for a given exciting current; and, third, to find the most economical distribution of copper in an armature bobbin with the given air-space and distribution of induction.—*Electrician*, Aug. 16th, 1901, pp. 633-35; Aug. 23rd, pp. 679-81.

The Electric Arc.—*The Mechanism of the Electric Arc.* By Mrs. Hertha Ayrton. The authoress of this paper, read before the Royal Society in June last, endeavours to show that, by applying the ordinary laws of resistance, of heating and cooling, and of burning to the arc, considered as a gap in a circuit furnishing its own conductor by the volatilisation of its own material, all its principal phenomena can be accounted for, without the aid of a large e.m.f., or of a "negative resistance," or any other unusual attribute.—*Electrician*, Aug. 16th, 1901, pp. 605, 606.

Three-Phase Current.—*The Elements of Three-Phase Theory.* By Alexander Russell, M.A. The author discusses several fundamental theorems in connection with three-phase theory, and arrives at solutions without considering it necessary to make assumptions as to the shape of the e.m.f. waves generated by the machines.—*Electrician*, Aug. 16th, 1901, pp. 639-43.

2. Electro-Chemistry and Metallurgy.

Accumulators.—*Recent Experiments with Accumulators of other than the Lead Type.* By Dr. St. v. Laszczynski. The author passes in review and comments upon most of the recently devised accumulators, including that of E. Jungner, of Stockholm, who uses silver peroxide (Ag_2O_2) as depolariser; T. v. Michalowski's accumulator, whose material for the positive electrode is oxide of nickel (Ni_2O_3), and who deserves credit for having been the first to draw attention to the peculiar thermic qualities of this oxide; this accumulator and the undoubted suitableness of oxide of nickel for the positive electrode, are discussed very fully. The author points out that the best material for the negative electrode still remains an unsolved problem. He alludes to the simplest form for the negative electrode, *i.e.* a zinc electrode, soluble in a lye of soda or potassium, as in the Wadell-Entz type, and returns to Jungner's accumulator, "with unchangeable electro type," having a negative electrode of porous copper and a positive electrode of peroxide of silver, which form is repeated in Edison's much-advertised accumulator. In conclusion, the author draws attention to the fact that these new attempts at constructing an efficient accumulator have, at all events, opened a wide vista of future possibilities.—*Zeitschrift für Elektrochemie*, Aug. 8th, 1901, pp. 821-7.

Electric Separators.—*Some Recent Developments in Magnetic and Electric Separation.* Short description of the Wetherill magnetic separator used for treating the tailings of the dressing works at Broken Hill, containing a mixture of galena, blende, and garnet, and employed at Lohmannsfeld, Germany, where two separators of this type are used for treating an ore containing galena, siderite, blende, and quartz. The article concludes with an outline of the latest improvement of Mr. Edison's separator and of Messrs. Sutton and Steele's separator, patented in the United States.—*Electro-Chemist and Metallurgist and Metallurgical Review*, Aug. 1901, p. 195.

Electro Chemistry.—*Electro-Chemical Industry.* By J. W. Swan, F.R.S. Under the above heading is published Mr. Swan's Presidential Address to the Society

of Chemical Industry, delivered at Glasgow on July 24th. The portion so far given consists of the introduction and the comments on copper refining, bullion refining, electrotyping, zinc and nickel plating, aluminium, sodium and magnesium, zinc, copper and nickel extraction processes, gold recovery from cyanide solutions, electrolytic alkali and chlorine industry, hypochlorites and chlorates.—*Electro-Chemist and Metallurgist and Metallurgical Review*, Aug., 1901, pp. 197-201. (*To be concluded.*)

Electrolytic Chemistry.—*The Beginnings of Electrolytic Chemistry.* By the Editor of *The Dyer.* The author characterises as a mistaken notion the view that the first electro-chemical products were potassium and sodium. Not to Davy, but to Cruikshank, belongs, according to him, the credit of pointing out how the just-discovered voltaic pile could be brought into the service of chemistry. In conclusion, the author shortly alludes to the later developments, and in a few words summarises the three main theories of electrolytic action. —*Electro-Chemist and Metallurgist and Metallurgical Review.* Aug., 1901, pp. 191, 192.

Phosphorus.—*The Manufacture of Phosphorus in the Electric Furnace.* The article describes an electric melting process for the manufacture of phosphorus, designed by Dr. F. J. Machalshe, of Long Island City, N.Y., and the author, alluding also to other electrical processes, as, for instance, that of Messrs. Readman and Parker at Wednesfield, and the process employed by the Deutsche Gold-und Silber Scheideanstalt at Frankfort-on-Maine, points out that the electric smelting of phosphorus is gradually displacing the old chemical process.—*Electro-Chemist and Metallurgist and Metallurgical Review*, Aug., 1901, pp. 193, 194.

3. Measuring Instruments and Methods.

Electric Measuring Apparatus. — "*Column*" *Measuring Instruments.* Description of a type of continuous-current voltmeter and animeter introduced into this country by Messrs. W. Blackwell & Co., which appears to have not yet been referred to in the electrical papers of this country. The principle on which the working of these instruments is based consists in causing the current to be measured to control the variation of pressure of a body of air in a closed vessel, this variation in turn being indicated by the rise and fall of a column of oil. It appears that these instruments are chiefly applicable to the switchboards of large electricity supply works and tramway power houses.—*Electrician*, Aug. 30th, 1901, pp. 717, 718. (Ill.)

4. Dynamos, Motors and Accessories.

Electrical Equipment.—*Electric Plant on the SS. "Discovery."* Description of a windmill and two dynamos, comprising a special lighting plant designed by Mr. Arthur Bergtheil, of the firm of Bergtheil & Young, for the exploration vessel *Discovery.* The windmill was constructed by Messrs. Alfred Williams & Co., while the dynamos were built by the Newton Electrical Works.—*Electrician*, Aug. 9th, 1901, p. 598. (Ill.)

Electric Elevators.—*The Electric Elevator in the Washington Monument.* By C. M. Lewis. Description of the electric elevator which has replaced the obsolete steam-driven elevator in the famous white shaft known as "The Sentinel of the Potomac." The article is introduced by a description of the excellent light and power plant in the monument.—*Electrical World and Engineer*, Aug., 1901, pp. 176-79. (Ill.)

Electric Generators.—*New Types of Direct-driven Generators.*—Description of generators of the Western Electric Company, U.S.A., embodying the results of the experience gathered in recent years, but maintaining all that has stood the test of experience in the older types of the company.—*Electrical Review* (New York), Aug. 19th, 1901, pp. 197, 98. (Ill.)

Hints on Winding.—*The Winding of Continuous Current Slotted Armatures.* Translation of an article on the subject by Mr. Alexander Rothert, published in the *Elektrotechnische Zeitschrift*, in which the author describes the methods of winding based upon the principle of economising to the utmost material and space, and upon a thorough investigation into the magnetic characteristics of the materials employed, and the cooling capacities of the machines.—*Electrical Engineer*, Aug. 23rd, 1901, pp. 266-69. (Ill.)

New Dynamo.—*The International Electrical Engineering Company's Dynamo.* Description of a dynamo placed upon the market by the company above named, which is distinguished externally by the graceful lines of form and compactness of construction, and which, on account of its special merits, has been selected by the Corporations of Hull, Dundee and Bristol for their lighting plants.—*Electrical Review* (New York), Aug. 16th, 1901, pp. 285, 286.

Rheocrat.—*Erie "Rheocrat" or Current Regulator.* Description of an apparatus designed by Mr. J. P. Erie for the purpose of varying the quantity of direct-current constant potential circuits so as to produce, if desired, a less degree of illumination, heat, or power.—*Western Electrician*, July 27th, 1901, pp. 58, 59. (Ill.)

5. Electric Transmission of Power.

Alternating Systems. — *Balancing a Three-Wire Alternating Secondary System.* By L. Denis. In this paper the author describes the method employed by the Jacques Cartier Water Power Company of Quebec, Canada, for keeping a three-wire secondary net-work in proper balance.—*Electricity* (New York), Aug. 21st, pp. 104, 105.

Polyphase Distribution.—*A Large Polyphase Workshop Distribution Plant.* Description of the polyphase plant of the New York Navy Yard at present nearing completion, and being one of the largest in the world. This plant will serve the new shops of the steam engineering department of that yard, and has a generating capacity of 1,200 kilowatts, and will supply power to more than 200 two-phase induction motors and to nine travelling cranes.—*Electrical Work and Engineer*, Aug. 17th, 1901, pp. 249-51. (Ill.)

Single-Phase Systems.—*The Prospects of Single-Phase Supply.* By W. E. Warrilow. The author points out that in the beginning of electric lighting in this country the single-phase alternating-current system was very generally adopted by the principal pioneer undertakings, and comes to the conclusion that the future prospects of the system are not as dull as many seem to suppose, nor is there any reason for declaring that the system is on the decline. There is every possibility, he thinks, of the single-phase system ultimately surviving and of becoming the standard means of obtaining electricity.—*Electrical Engineer*, Aug. 23rd, 1901, pp. 271-73. (Ill.)

6. Electric Lighting.

Arc Light.—*The Bremer Arc Light.* This is a digest of two patent specifications, the one on the material of arc light electrodes, and the other on reform of arc lamps, granted to Mr. Hugo Bremer, of Nauheim, Germany, for whose arc light high claims have been made on the Continent during the last twelve months.—*Electrical World and Engineer*, Aug. 17th, 1901, p. 259.

Lighting Plants.—*The Kings County Station of the Edison Illuminating Company of Brooklyn.* Description of one of the two main generating plants, known as the King's County Plant of the Brooklyn Edison Company.—*Electrical Review* (New York), Aug. 17th, 1901, pp. 191-95. (Ill.)

7. Telegraphy and Telephony.

Cable-Testing. *A New Method of Localising a Fault in a Single Cable.* By Walter Betts. The author describes a method designed by him for the localisation of a fault in a submarine cable, when a second cable is not available, which he claims to be approaching in accuracy and simplicity the well-known loop test.—*Electrical Review*, Aug. 16th, 1901, pp. 255, 256. (Ill.)

Coherers. *The Development, Construction, Operation, and Function of Electric Wave Detectors.* By A. Frederick Collins. The author discusses the gradual evolution of the so-called coherer from the micrometer spark-gap detector of Professor Hertz to the more recent types, including the author's decoherer. — *Electrical World and Engineer*, Aug. 17th, 1901, pp. 251-53. (Ill.)

Improved Telephony.—*An Interesting Automatic Telephone Plant.* Description of a telephone plant installed in the town of George, Iowa, U.S.A., by the Globe Automatic Telephone Company, Chicago, which, it is said, has proved so successful as to increase the number of subscribers by 50 per cent., as it reduces the operation of calling up to the utmost simplicity. Its chief feature is a keyboard, containing three vertical rows of figures from zero to 9, and for each of these a movable key. To call up No. 325, for instance, the first key on the left is placed at 3, the second at 2, and the third at 5. Then the receiver is taken down, and the conversation between the caller and 325 can begin. If 325 is talking to somebody else when called up, the caller is at once notified, and he remains free to make any other conversation he may desire.—*Electrical Review* (New York), Aug. 17th, 1901, p. 198. (Ill.)

Telephony.—*Military Telephony in New York State.* Description of telephone experiments made at the recent encampment of the National Guard of the State of New York, at the State Camp, Peekskill, during the annual practice of shooting of the batteries of the light field artillery, when the results were transmitted from the target over a line three miles long, finished two hours from commencing work, the work being done in exactly the same manner as that which would characterise the establishment of the line in actual warfare.—*Electrical World and Engineer*, Aug. 3rd, pp. 182, 183. (Ill.)

—— *The Telephone in Railway Service.* Description of the installation of an efficient telephone system for despatching trains, etc., by the Delaware, Lackawanna, and Western Company. In order to retain a record of the messages they are written down exactly as were the telegraphic messages, but in order to save time printed forms are used containing the phrases constantly used, and only details to be filled in are sent by telephone. It is the intention later on to use a system combining telephone and phonograph, devised by Mr. Edison. Meanwhile the innovation has proved very successful, and apart from being in use for despatching trains, enables every official to personally communicate with every other official in much less time than by telegraph, the two telegraph operators being entirely eliminated.—*Electrical World and Engineer*, Aug. 10th, 1901, pp. 217, 218.

Wireless Telegraphy.—*A New System of Space Telegraphy.* Description of a system of wireless telegraphy which is an entire departure from Marconi's. The receiver is the joint invention of Lee de Forrest, a graduate of Yale University, and Mr. Edwin H. Smythe, of the engineering department of the Western Electric Company of Chicago, while the sending apparatus has been developed by Professor E. Freeman, C.E., associate professor of electrical engineering at the Armour Institute of Technology.—*Western Electrician*, July 27th, 1901, pp. 49, 50. (Ill.)

—— *The Latest Progress in Spark Telegraphy.* By Professor Slaby. Extract from a lecture delivered at the forty-second general meeting of the Society of German Engineers. The author describes the latest forms of connections of the wireless telegraph apparatus made by the "Allgemeine Elektricitäts Gesellschaft," and points out that there are definite limits to the extension of this kind of telegraphy which can be foretold already, and that the future development lies exclusively in the direction of producing higher electrical pressures. He adds that what we have used so far is very modest in comparison with the wonderful achievements of Mr. Tesla, as may be seen from a very remarkable photograph accompanying this extract of Professor Slaby's lecture.—*Electrician*, Aug. 23rd, 1901, pp. 672, 673. (Ill.)

8. Electric Traction,

Electric Railways.—*The Naples-Aversa-Caivano Inter-urban Electric Railway System.* By Cesare Pio. The density of population in the city of Naples and suburbs affords excellent traffic conditions for suburban steam railroads. Such a line was opened to traffic on April 1st, and contains many interesting features. The high price of coal has rendered it necessary to reduce the loss from transmission to a minimum. Between the only power station at Naples and the sub-station at Melito three-phase current is used; as soon as the traffic conditions render it advisable the line will be continued to Afragola. The present equipment of the power station consists of three steam engines of 350 h.p. each, built by the Brunner Company. One of these is direct coupled with an alternator of 5,000 volts, another to a direct-current six-pole generator running at 125 r.p.m., feeding the first part of the time, while the third is kept in reserve, and is connected both to a direct-current generator and to a three-phase alternator similar to the one first mentioned. The contract for the electric equipment was obtained by the Union Elektricitäts Gesellschaft, Berlin.—*Street Railway Journal*, Aug., 1901, pp. 79-82. (Ill.)

—— *The Inter-urban Railways of Ohio.* Ohio occupies a prominent position among those States that have inaugurated a transformation of steam railways into electric railways. There are about 9,000 miles of the former in existence, and electric lines in towns and villages comprise about 898 miles, while suburban lines and connecting lines between different places aggregate to about an equal length. There are, however, in actual process of construction no less than 1,435 miles of road, so that the total length of track devoted to electric traction will soon be 3,200 miles, *i.e.* more than a third of the length of track serving for steam traction. The article gives an account of this progress, which will assume much greater dimensions in the near future, and mentions in detail the many lines projected by the syndicates and capitalists controlling the enterprise.—*Street Railways Journal*, Aug. 1901, pp. 107-119.

Electric Tramways.—*The Dublin United Tramways Systems.* The author points out that, owing to different conditions and circumstances, electric traction plants in this country are sufficiently different from those existing in the United States to render the latter of little value to the British engineer if he desires to find suggestions for his new work, and in this country electric traction is still of so recent a date that it will be difficult for him to discover what he requires in the plants existing in the United Kingdom. Only very few traction plants in this country have sufficiently developed to aid him. Among these few, however, the tramway system is, according to the author, the most instructive, and for this reason he enters into a detailed description of its present conditions and its development.—*Electrician*, Aug. 9th, 1901, pp. 587-92; Aug. 23rd, pp. 667-71.

Rapid Transit.—*High-Speed Electric Traction between Milan and the Italian Lakes.* The abundance of water-power in Northern Italy has induced the railway companies in that part of Italy to take into consideration the transformation of many of the shorter sections of their system into electric lines. The article deals with the latest of these, which establishes a connection between Milan and the Lakes.—*Street Railway Journal*, Aug., 1901, pp. 99-107. (Ill.)

—— *The System of the Atlanta Rapid Transit Company.* The railway lines of this company are supplied with current from the works of the Georgia Electric Light Company, and have been carefully planned, forming the quickest communication between the most important business districts and suburban residential portions. The alternating current of the central lighting station is transformed by rotary transformers into continuous current, and as such furnished to the traction system.—*Street Railway Journal*, Aug., 1901, pp. 73-8. (Ill.)

MARINE AND NAVAL ENGINEERING.

1. War Vessels.

Cruisers.—*H.M.S. "Leviathan."* Description of the new first-class cruiser of the above name, which promises to be one of the fastest ships in H.M. Navy. She has a length between perpendiculars of 500 ft., an extreme breadth of 71 ft. 13 ins., a normal displacement of 14,160 tons, while the i.h.p. is 30,000, and the speed is estimated to be 23 knots.—*Steamship*, Aug. 1901, p. 51.

2. Freight and Passenger Vessels.

Cape Liners.—*Launch of a Union Castle Liner.* Description of the *Walmer Castle*, the fourteenth vessel built by Messrs. Harland & Wolff for the Cape trade, being 585 ft. 6 ins. long by 64 ft. beam by 42 ft. 9 ins. deep,

and registered as a vessel of 1,300 gross tons.—*Steamship*, Aug. 1901, p. 52.

Great Ships of the Past.—*Details of Construction of the Famous American Clipper ship "Great Republic."* Description of one of those great American wooden clipper ships of the past century, which have never been surpassed in size nor probably in performance afloat. The builder of the *Great Republic*, of Boston, was Donald McKay, who constructed her about the middle of the last century, and the description given of the details was circulated privately and claims to be written by "a sailor." It is very quaint and entertaining.—*Marine Engineer*, Aug. 1901, pp. 320-24. (Ill.)

3. Pleasure Boats.

4. Equipment and Machinery.

Marine Engines.—*Compound* v. *Triple Expansion Engines.* By E. A. M'Allister, First Assistant Engineer R. C. S. The author draws attention to the reiterated statement that, although the modern triple-expansion engines are far more economical on long trips, the compound engine is equally as good for harbour duties, and on short trips. Not only are there many who argue thus, but there is evidently a belief in the correctness of the assertion, since at this moment several compound engines are in course of construction. In order to show, however, the absolute fallacy of the above assertion, Mr. M'Allister gives the monthly coal consumption for one year of two boarding boats in the revenue cutter service, U.S.A., whose duties are to place Customs officials on board incoming steamers at the port of New York. The data show that the *Hudson*, with its triple expansion engine, burned 68·42 tons less than the *Calumet*, with her compound engine, and although in all other respects the two tug-boats are equal.—*Marine Engineering*, Aug. 1901, p. 318.

—— *Marine Engine Governors at the Glasgow Exhibition.* Description of an ingenious device for controlling the speed of marine engines, exhibited at Stand 500, Machinery Hall by the Aspinall's Patent Governor Company, 7, Strand Street, Liverpool.—*Steamship*, Aug. 1901, p. 75. (Ill.)

5. Miscellaneous.

Shipbuilding.—*Lengthening a Steamer.* The short text accompanying two full-page illustrations gives the essential data. The ship in question was the ss. *Hayle*, owned by Messrs. Harvey & Co., Ltd., of Hayle, Cornwall, and built by them and fitted out complete in 1893. The original dimensions were 150 ft. by 24 ft. by 11 ft., the length to be added by Messrs. Wordey Carney, (Southampton), Ltd., is 31 ft. 6 ins. on the water-line, making her 181 ft. 6 ins. on the water-line.—*Marine Engineer*, August 1st, 1901, p. 159. (Ill.)

—— *A Solution of the Vibration Problem.* B. J. H. Macalpine. Under this heading is reproduced a paper on the subject, read by the author at the 42nd Session of the Institution of Naval Architects.—*Marine Engineer*, August 1st, pp. 179-82. (To be continued. Ill.)

Shipyards.—*Shooter's Island Shipyard.* The article points out that New York after leading the world in ship-building in the days when steam was in its infancy, and steel and iron construction unknown, had later to give way to the Delaware and Eastern ports. She is, however, now regaining her former position. The bulk of the text is devoted to a description of the shipyard of the Townsend and Downey Ship-building and Repairing Company, at Shooter's Island, at the mouth of Newark Bay, one mile from the Kill von Kull.—*Marine Engineer*, August, 1901, pp. 326-30. (Ill.)

MECHANICAL ENGINEERING.

1. Boilers, Furnaces and Fuel.

Boiler Accessories.—*The Dean Cleaner for Fire and Water Tubes.* This is a short account of a boiler-tube cleaning device, known as the Dean Steam Tube Cleaner, constructed and introduced by the Power Specialty Co., of Buffalo, N.Y. It is practically a little engine operated by steam or compressed air, but at the end what would be the piston rod on a large engine, is a small iron vibrator, or oscillator, made with the same curve as the tube.—*The Engineer* (Cleveland), Aug. 15th, 1901, pp. 301-7. (Ill.)

Fuel.—*Fuel Value of Saw Dust.* This is an extract from "Ryerson's Technical Library," in which Mr. F. W. Cappelen, City Engineer of Minneapolis, gives a comparison of the fuel value of saw dust and pine edgings compared with Youghiogheny coal, in which he comes to the conclusion that a card (128 cu. ft.) of saw dust has the fuel equivalent of 538 lbs. of coal in actual practice.—*American Engineer and Railroad Journal*, August, 1901, p. 257.

2. Compressed Air.

Air Compressors.—*Ingersoll-Sargeant Air Compressors.* By W. C. Popplewell, M.Sc., Assoc.M.Inst.C.E. In this instalment of the author's contribution, so-called "two-stage" air compressors, constructed by the above firm, are dealt with. Such two-stage compressors are specially suited for all pressures higher than from 60 to 80 lbs.—*Mechanical Engineer*, Aug. 10th, 1901, pp. 187-89.

—— *Riedler Air Compressors.* By W. C. Popplewell, M.Sc., Assoc.M.Inst.C.E. Under this heading is published an instalment of a serial contribution on the subject of air compressors, dealing with a type designed by Professor Riedler, the distinctive feature of which consists in the mechanical control given to the valves. The makers are Messrs. Fraser & Chalmers, London.—*Mechanical Engineer*, Aug. 24th, pp. 252-54. (Ill.)

3. Engines and Motors.

Automobiles.—*Regulations for Fast Long-Distance Automobile Test in America.* Under this heading are published the complete rules and regulations drawn up by the Automobile Club of America with reference to the 500-miles endurance contest during the week beginning Monday morning, Sept. 9th, 1901, which consisted of a run starting from the club house, Fifth Avenue, and Fifty-eighth Street, in the City of New York, and terminated at Buffalo, Saturday afternoon, Sept. 14th.—*Electric World and Engineer*, Aug. 3rd, pp. 180, 181.

Gas Engines.—*Otto Engines for Holland Submarine Boats.* The Otto Gas Engine Works, of Philadelphia, recently built a series of gasoline engines, especially constructed for submarine boats. Nine of them have been completed, seven of which are for the U.S. Navy; five of these engines are being built for the British Admiralty, and others are now under construction. The engines described are of the "Otto" cycle type, with four single-acting cylinders, inverted, with crank-shaft below, and supported by three main bearings of the engine-bed. The engines are perfectly balanced, and the vibration when working the boat is reduced to a minimum.—*American Manufacturer*, Aug. 22nd, 1901, pp. 1522, 1523. (Ill.)

Motor Cars.—*The Gaillardet Motor Car.* Description of motor cars now being built at Suresnes, near Paris, by M. Gaillardet, differing considerably in detail from most of those of other manufacturers. Among other novelties there is a curious combination of the mechanism hitherto used in voiturettes of the "New Orleans" type with the usual general arrangements of other and larger kinds of vehicles.—*Automotor Journal*, Aug. 1901, pp. 526-28. (Ill.)

Motor Wagons.—*The Musker Coke-Fired Wagon.* Under this heading the essential constructional details of the coke-fired and oil-fired wagons of Messrs. C. and A. Musker, Ltd., are given, accompanied by the detail drawings.—*Automotor Journal*, Aug. 1901, pp. 518-24. (Ill.)

4. Power and Transmission.

Belts.—*Power Transmission by Belts.* By Forrest R. Jones. In this contribution the author analyses the system of belt transmission in which idlers are introduced, and calculates the effect for three diameters of pulleys—viz. 3 ft., 6 ft., and 9 ft.—*American Machinery*, Aug. 1901, pp. 383—85. (Ill.)

Chains.—*Chains and Chain Gearing.* By Charles Pietz. This is an abstract of a paper read by the author before the Engineer's Club at Philadelphia.—*American Machinery*, Aug. 1st, 1901, pp. 388-40. (Ill.)

5. Machine Works, and Foundry.

Dies.—*A Twisting Die.* By C. H. Rowe. Description of a die for twisting the ends of sheet brass, $\frac{1}{8}$ in. thick and $\frac{1}{2}$ in. wide; being readily adaptable also for other work of similar character. Moreover, any length of work can be twisted, and the twist may be made at some distance from the ends by simply making the cylinder of a corresponding length.—*American Machinist*, Aug. 17th, 1901, p. 857. (Ill.)

Machine Works.—*The New Works of the Becker-Brainard Milling Machine Company.* The article describes the newly constructed and equipped works of the firm above named, at Hyde Park, Mass. Following the modern tendency toward specialisation, the Becker-Brainard Company confine their output entirely to one line of article—namely, milling machines, including gear-cutters.—*American Machinery*, Aug., 1901, pp. 373-8. (Ill.)

6. Machine Tools.

Machine Tool Shops.—Shops of John Lang & Sons, Johnstone, Scotland. This is a description from an American point of view of what the author says impressed him as one of the best and most progressive machine-tool building establishments in Great Britain, *i.e.* the works of John Lang & Sons at Johnston, near Glasgow. The work done is mostly light, small and medium lathes being the specialty of the firm, who, unlike most other British manufacturers, confine themselves to comparatively few lines.—*American Machinist*, July 20th, 1901, pp. 731-33. (Ill.)

Tools.—*Tube-Forming Tools.* By B. J. Dougherty. The main portion of this article is devoted to a description of a set of tools for forming taper tubes from tin and other light-gauge metals. The method is used in making tin pit spouts, dipper handles, blowhorns, oil-can spouts, tin whistles, or spouts, etc. These tools have the advantage over others, from a financial standpoint, that one punch and die only is required to complete the tube; but three blows only must be struck, thus making three operations, and it is best to use them in a fast press.—*American Machinist*, July 20th, 1901, pp. 735, 736. (Ill.)

7. Refrigeration and Cold Storage.

Cold Storage Plants.—*Glasgow's New Ice Factory and Cold Stores.* Description of the latest ice and cold-storage plant erected in Glasgow, being that of Messrs. William McLachlan & Co., of 126 Bridgegate, a firm well known in the wholesale fish and ice trade of Scotland. —*Ice and Cold Storage*, Aug. 1901, pp. 201-5. (Ill.)

Vacuum System.—*Vacuum.* A leader-writer, under the above title, comments on the vacuum system of ice-making, which recently seems to have supplanted the liquid air swindle, and one of whose mysteries is an occult kind of vapour absorbent.—*Ice and Cold Storage*, Aug. 1901, pp. 211, 212.

8. Miscellaneous.

Dynamometers.—*Hydrodynamometers.* By R. Grimshaw. The author describes a type of dynamometer in which hydraulic pressure replaces metal springs for measuring and resisting the torsion of other force exerted in transmission, without absorbing it, as the Prouy brake. The inventor, M. H. Bourow, a Frenchman, has devised two special apparatus—a hydrodynamic bearing and a hydrodynamic shaft-coupling hydrodynamometer—both of which are dealt with.—*American Machinist*, Aug. 10th, 1901, pp. 832, 833.

Hydraulic Rams.—*A Large Hydraulic Ram.* By Daniel W. Mead. The ram in question is situated in the village of West Dundee, Ill., U.S.A., and used to force water into the tower of the water-works. It stands 20 ft. high, the principal height being taken up by a wrought-iron air chamber about 12 ft. high and 29 ins. in diameter. The water from the springs is brought to this ram in a 10-in. cast-iron pipe. The waste or pulse valve of the ram is 8 ins. in diameter, and is raised from its seat by a heavy spiral spring, made from $\frac{3}{4}$-in. square steel. The lift of this valve is about $\frac{1}{4}$ in. The pulsations are very slow, running from twelve to fourteen in a minute. The discharge or check valve consists of an enlarged valve chamber, in which are placed a number of the regulation pump valves, having bronze seats, rubber valves, bronze guards, and cylindrical bronze springs. This ram is capable of pumping all the water needed by the village for seven months in the year. During the hot summer the fire-pumps are operated for about thirteen hours to supply water for sprinkling purposes.—*Engineering Record*, Aug. 24th, 1901, p. 174.

Scales.—*The Clarke Automatic Scales.* Description of a new automatic scale, in which most of the drawbacks of other types are removed. These scales are placed upon the market by the Clarke Automatic Scales Company, of 29, Broadway, New York.—*American Machinist*, Aug. 24th, 1901, pp. 893-5. (Ill.)

MINING.

1. Coal and Coke.

Coal Deposits.—*Dredging for Coal.* Description of a peculiar coal mine—"if we may be permitted to call a mine an open-cut operation which looks more like Chicago drainage canal than a coal mine," says the author—called the Mission Field Coal Mine, in Vermillion County, Illinois, about five miles west of Danville, on the Big Four and the Chicago and Eastern Illinois Railway. The coal in Vermillion County lies about 100 ft. under the normal surface of the ground, but in some places, in the river bottoms, the surface has been washed away. All kinds of devices were tried to take advantage of this fact in the mining operations, but it was not until 1894, when the Butler steam shovel and cableway were tried, that real progress was made. Since then many millions of yards of earth have been handled by these shovels and a large amount of coal shipped, but it is only within the past few months that the coal could be handled by mechanical means, which are described in this article.—*Mines and Minerals*, Aug. 1901, pp. 5, 6. (Ill.)

MUNICIPAL ENGINEERING.

1. Street Lighting.

2. Gas and Gas Manufacture.

Gas Works Practice.—*Mechanical Conveying of Coal and Coke in Gas Works.* By Henri Laurain, of Paris. Under this heading is published a paper by the author, read at the annual meeting of the Société Technique, in which he deals with the working of the De Brouwer conveyors and hot-coke conveyors in general. The first portion is devoted to the mechanical conveyance of the coal up to, and its deposit in the retorts; in the second, with the mechanical conveying of the coke coming from the retorts up to and including the putting of it into sacks, carts, railway trucks, or heaps—all, of course, after sorting.—*Journal of Gas Lighting*, Sept. 3rd, 1901, pp. 567-70. (Ill.)

3. Sewerage.

Sewerage.—*Difficult Sewer Reconstruction.* By Harrison Sonder, Civil and Mining Engineer. This heading refers to a description of repairing work done at a sewer in Philadelphia, at Thirtyeighth and Brown Streets. The sewer at this place was circular in section, 4 ft. 6 ins. in diameter, but it was crushed into an oval shape 5 ft. 8 ins. wide by 4 ft. 3 ins. high for some 90 ft. A portion had formerly been rebuilt, and at the junction of the old sewer and the rebuilt portion a large opening had gradually formed, and the movement of the made ground toward the sewer was likely to do damage to neighbouring houses, as a cavity 12 ft. high was discovered above the sewer during the last reconstruction. The repair operations were rendered more difficult by presence of many water, gas, and drainage pipes, and the fact that by the breaking of the upper sewer another cavity was formed under the street, and a heavy wagon falling through broke a water main.—*Engineering Record* Aug. 31st, 1901, p. 198.

4. Water Supply.

Water Reservoir.—*A Concrete Reservoir Lining at Salt Lake City.* The excavations for the distribution reservoir referred to were begun about 12 years ago, and some of the pipe-collections for the work were laid. Afterwards operations were suspended for a few years, but were finally resumed from revised plans prepared by Mr. F. C. Kelsey, city engineer. The reservoir has heavy concrete lining on the bottom and slopes, and a concrete retaining wall, which have numerous features of interest dealt with in this article.—*Engineering Record*, Aug. 24th, 1901, pp. 174-76.

5. Pavements.

Street Paving.—*The Development of Bituminous Pavements.* The author reviews the history of asphalt paving from the accidental discovery of the utility of natural rock asphalt from the mines in the Val de Travers, Canton Neufchatel, Switzerland, in 1849 to the present time.—*Engineering Record*, Aug. 31st, 1901, pp. 19 and 99. (Ill.)

RAILWAY WORK.

1. Motive Power and Equipment.

Locomotives.—*Express Locomotive, South-Eastern and Chatham Railway.* Description of several new engines constructed from the design of Mr. Harry S. Wainright, locomotive engineer of the above-named joint lines, excellently fitted for heavy roads, the boat trains, usually equal to about twenty-two vehicles, and weighing behind the tender 260 tons, easily keeping time. The incline of 12 miles out of London has been surmounted with 200 tons behind the tender at 40 miles an hour.—*Engineer*, July 19th, 1901, p. 71. (Ill.)

—— *Tandem Compound.* Under this heading is described a new departure with the Schenectady Locomotive Works, being a compound with tandem cylinders, built for the Northern Pacific Railway. The cylinders are 15 and 28 by 34 ins., and there are a number of interesting novel features.—*Railway and Locomotive Engineering*, Sept., 1901, p. 381. (Ill.)

—— *American Locomotives in England.* By a Locomotive Engineer. In the fourth article on the subject, the author deals with the general question of the structural differences between American and English locomotives, in their bearing on the suitability of each for railways abroad, and in respect of the influence they exert on the competition between British and American makers in neutral markets.—*Engineer*, Aug. 9th, 1901, p. 139.

—— *Tank Locomotive, Glasgow Exhibition.* The locomotive in question was built by Andrew Barclay, Sons & Co., Ltd., of Kilmarnock, a firm of more than sixty years standing. Although this side-tank locomotive, named "Alexandra," has cylinders only 16 in. in diameter, the firm are regularly building engines up to 18 in.-cylinders, and have plant for sizes up to 20 in.-cylinders.—*Engineer*, Aug. 23rd, 1901, p. 198. (Ill.)

—— *Inspection Locomotive—Chicago, Burlington and Quincy Railroad.* Description of a locomotive built by the Chicago, Burlington and Quincy Railroad, U.S.A., for the use of its general manager, being a much more powerful engine than the general type of inspection engines, and intended to haul one or more business cars when necessary.—*American Engineer and Railroad Journal*, Aug., 1901, p. 241. (Ill.)

—— *Four-Cylinder Tandem Compound Locomotive, Northern Pacific Ry.* The locomotive described in this contribution has given satisfation during more than a year's trial, and its builders, the Schenectady Locomotive Works, have received an order for 26 for the road above named, while, in addition, an order for 40 of the same type has been given by the Atchison, Topeka & Santa Fé Railroad. It will henceforth be known as Class Y2, and will be used in freight service on the Pacific Division.—*American Engineer and Railroad Journal*, Sept., 1901, pp. 271-8. (Ill.)

Locomotive Cab.—*Cab Arrangement of Plant Engines.* Description of the arrangement of operating appliances in the latest locomotive purchased by the Plant system of railways, in which the principle that the engineer should have every handle he requires to operate within easy reach is excellently realised.—*Locomotive Engineering*, May, 1901, p. 190. (Ill.)

Passenger Cars.—*New Ventilating System for Passenger Cars.* Under this heading a very detailed description is given of a ventilating system which had been designed with regard to the experience gained during several years of study, and has been on trial for five years on the Pennsylvania Railroad, 200 cars having been furnished with the necessary appliances, with very satisfactory results.—*American Engineer and Railroad Journal*, June, pp. 177-81.

2. Permanent Way and Fixtures.

Railway Stations.—*Victoria, Manchester.* Under this heading Mr. Thomas J. Matthews, describes the greatest English railway-station out of London, and perhaps the busiest, for its size, in all England—*i.e.* the head-quarters of the Lancashire and Yorkshire Railway.—*Railway Magazine*, June, 1901, pp. 481-90. (Ill.)

—— *Edinburgh (Princes Street) Caledonian Railway.* Interesting description of the present station, built by Messrs. Cunningham, Blyth & Westland, engineers, and Messrs. Peddie and Kinnear, both Edinburgh architects, at the cost of £120,000. The works were commenced in the latter part of 1890, and the greater portion of the station was open to traffic in 1893.—*Railway Magazine*, July, 1901, pp. 49-56. (Ill.)

3. Transporting and Conducting.

Special Trains.—*Special Trains on Railways. What they cost, who use them, and why.* By G. A. Wade, B.A. From this interesting sketch it appears that on six of the chief British railways a special for a run of 40 miles costs from £10 5*s.* 4*d.* to £17.—*Railway Magazine*, June, 1901, pp. 512-18. (Ill.)

Train Services.—*London-Suburban Train Services.* By W. J. Scott, B.A. (Associate Society of Engineers). Under this heading appears the first of a series of articles dealing with the facilities given by the various lines to Londoners living in, or desiring to visit, the more remote suburban regions. The beginning is made with the Great Northern.—*Railway Magazine*, June, 1901, pp. 503-10. (Ill.)

—— *The London and Suburban Train Services.* 1.—Great Northern (concluded). By W. J. Scott, B.A.—*Railway Magazine*, July, 1901, pp. 21-26. (Ill.)

4. New Projects, Lines in Construction or Recently Completed.

African Railways.—*The Lagos Government Railways.* Description of the interesting railway from Lagos to Obadan, opened to traffic in March last, which probably will be continued to the Niger in the near future. This railway is the property of the Lagos Government, the cost being defrayed by the issue of a loan, and was built by Messrs. Shelford & Son, Westminster.—*Engineer*, June 28th, pp. 662, 663. (Ill.)

Rolling Stock.—*Rhodesian Railway Rolling Stock.* Description of some typical wagons of the most modern style, built by the Lancaster Railway Carriage and Wagon Company for coal and goods traffic on the Rhodesian Railway, including a 20-ton low-sided wagon, a 30-ton high-sided wagon, and a 20-ton covered wagon with guard's apartment. — *Engineering*, Aug. 9th, pp. 182, 183. (Ill.)

Water Gauge.—*Locomotive Water Gauge.* The water gauge described is of a pattern fitted on Midland locomotives, and the illustrations accompanying the text are very clear. This gauge is made by Messrs. Charles Wilson & Co., of Birmingham, and fulfils satisfactorily the various qualifications which are demanded in a new gauge, above all, it possesses great facilities for cleaning, so that persons charged with this duty shall have no temptation to shirk it.—*Engineer*, Aug. 2nd, 1901, pp. 117. (Ill.)

NEW CATALOGUES.

Illustrated Catalogue of Bridge's Ice-Crushing Machinery. David Bridge & Co., Castleton Iron Works, Castleton, Manchester; London office: 35, Queen Victoria Street, E.C.

Under the above title Messrs. David Bridge & Co. place before their customers and intending buyers a tastefully printed catalogue specially devoted to ice-crushing machinery and a variety of mechanical devices required in the ice trade. This class of machinery represents one of the specialties of this well-known engineering firm, and is manufactured in their new works in Castleton, recently erected. The ice-crushers, which are usually belt-driven, but are supplied also by the firm with direct-coupled motors, are distinguished by great solidity and are powerfully geared. They are made in various sizes, from a small crusher which crushes 1½ tons per hour to the largest type so far constructed, which, when properly fed, can easily dispose of 30 tons during the same space of time. A machine of this type is shown in one of the illustrations accompanying the text of the catalogue. Among other mechanical devices connected with the ice trade, and built by Messrs. D. Bridge & Co., are ice elevators and conveyors, and ice tools of every description.

A great number of additional specialties are described and illustrated in the new and revised catalogue of the firm just issued under the title "Illustrated Catalogue of Heywood & Bridge's Improved Patent Friction Clutch (combining 1899 Patent)," which is as attractive in appearance as the above-mentioned catalogue, being clearly printed and illustrated by excellent engravings. A number of very appreciative testimonials by well-known firms justify the claims which Messrs. David Bridge & Co. make regarding the quality and efficiency of their manufactures.

Machine-cut Toothed Gearing (Patent "Buffoline"), Noiseless Wheels and Mallets. Price List. "Buffoline" Noiseless Gear Company, Contractors to the British Government, Chapel Street, Levenshulme, near Manchester.

Under this heading is published a small catalogue by the firm above named, containing a description of their "Buffoline Noiseless Pinions," which are claimed to be superior to metal wheels, not only on account of their noiseless working, but also on account of the absence of vibration, the facts that they require no lubrication, are very light in weight, and yet have double the strength of cast iron, and that they work with considerably less friction. These pinions are suitable for electric motors, pumps, cranes, printing and textile machinery, motor cars, and many other kinds of machinery. The description is followed by instructions, showing intending customers how to order, and by a full price list of pinions of given width of tooth and pitch diameter, to which is added the cost of bushing "Buffoline" wheels, of planing the teeth of bevel wheels, and of the cutting of spur wheels, together with rules for obtaining any desired size of gear wheel. Another specialty described are the so-called "Buffoline" mallets, with steel shafts, by which, as the patentees claim, the problem of driving a spindle or shaft into a casting for the purpose of turning, and also for firing or driving, without injury to the spindle and without "burring" the ends, has been solved.

The Engineering Price List has always been maintained on a high plane of excellence, but at no time has its utility in the extension and development of the British engineering trades been so great as it is to-day. Its usefulness increases with each issue, and it is becoming more and more recognised as the only medium which adequately represents the growing industries connected with the engineering, building, and kindred trades.

New Catalogue of Messrs. Hartley & Sugden, Ltd., Welded and Riveted Boiler Manufacturers, Atlas Works, Halifax, England.

In the above publication Messrs. Hartley & Sugden have placed before the public a description, couched in concise but lucid language, of the various types of their widely-known boilers and steam-heating apparatus. The text contains a great number of excellent engravings. Other creditable features of this trade catalogue are that it contains a sufficiently full index, enabling the reader to find the information he wants in a minimum of time, and that among the data given regarding each boiler are not the approximate, but the actual heating powers, derived from carefully-noted observations while in work. Messrs. Hartley & Sugden have found on calculation that one square foot of direct heating surface will heat with economy, under average conditions, 35 ft. of 4-in. pipe and flues in proportion. They preface the description of their boilers by a number of important hints regarding the construction of flues, the placing of soot-boxes, fuel most suitable for one or the other type of boiler, &c.; and announce that they are ready to supply any design of boiler mentioned in this catalogue in welded steel, and furnish also copper boilers, either riveted or brazed, in all shapes and sizes. To sum up, the new catalogue of Messrs. Hartley and Sugden is both convenient and instructive, and intending purchasers of heat apparatus will find it profitable to consult it.

ERRATA.

Page 212, Fig. 3. *For* "1,300 tons" *read* "7,300."

Page 213, Fig. 4. *For* "Dock 3,690 metres" *read* "Dock No. III. 690 metres."

Relative to our remarks on Atlas Metal in our September issue, page 271, the Company inform us that the speciality of their metal is not that they use no tin at all, but that they use tin in proper proportions to make a metal quite equal to those highly expensive metals which contain tin as a primary basis.